DEVELOPMENTAL PATHOLOGY

A Study in Degenerative Evolution

By

EUGENE S. TALBOT, M.S., D.D.S., M.D., LL.D.

Professor of Stomatology, Bennett Medical College, (Loyola University);
Corresponding member, Budapest Royal Society of Physicians,
honorary president International Assooiation of
Stomatology, 1907, Paris.

WITH 346 ILLUSTRATIONS

RICHARD G. BADGER
THE GORHAM PRESS
BOSTON

The Gorham Press, Boston, Mass., U. S. A.

It has been the author's privilege to be the pupil
of
PROF. JAMES GEORGE KIERNAN
to whom
this book is respectfully dedicated

PREFACE

THE object of this book, tersely stated, is to show:

First, that the ontogeny of man, his structures and organs, is a modified recapitulation of his phylogeny in development.

Second, that as the vertebral phase appears early in embryogeny, an unstable nervous system checked by parental defects, eruptive fevers, and other agencies at the periods of stress in the child, affects phylogeny and ontogeny.

The paramount practical purpose of the book, therefore, is to correct current erroneous conceptions of heredity, by showing that neither excessive nor arrested development is inherited directly from the parent. Children born with structures and organs which exhibit a departure from the type, are said to inherit these defects. Upon investigation, however, none of the defects are to be found in the family for generations; in the seeming default of heredity to account for the departures from the type, the ordinary mind fails to understand them. The real key to the situation lies in the truth that human heredity cannot be considered to any purpose, without taking into account intrauterine education, environment and development. With the object of presenting these conditions in their proper relationship this work is offered. It is by no means complete. Many pathologic conditions of structures and organs are necessarily not enumerated. It is hoped that other workers in this field will continue investigations and carry views, herein outlined, to a more extended issue. It is not intended to take the place of any other researches detailed in preceding works, since this work is intended merely to lay down general principles.

Much of the material on phylogeny of the teeth is taken from Richard Owen, (Odontography) and Tomes, (Dental Anatomy), standard works.

The author has utilized facts, collected by other writers. Occasionally the exact language is cited. The works consulted with names of their authors appear in the back of this work. These works are especially adapted to form a part of the working library of every practitioner.

There are many repetitions, beneficial, since they familiarize the student with general laws applicable to each pathologic condition.

The author is under obligations to Dr. Charles H. Ward, of Rochester, New York, for preparation and arrangement of the fetal and infant skulls, especially prepared for this work; to Dr. Vida A. Latham for assistance in microphotography of the dental pulp; to Dr. James G. Kiernan for suggestions; to Dr. Thomas G. Atkinson for assistance in preparing the manuscript for the press; to Capt. M. P. Evans of the Identification De-

partment of Police of the City of Chicago, and to the Superintendent of the Illinois State Reformatory, at Pontiac, for photographs of criminals; to Miss Helen Dunning for illustrations and to Blomgren Bros. & Company, of Chicago, for electroplates.

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INTRODUCTION

DEVELOPMENTAL pathology, while rather extensively considered in surgery, in the domain of tumors, of orthopedics, and also in connection with abnormalities of the liver and also of the bones so far as cervical ribs are concerned, has not received the attention which its relations to the etiologic moment of disease and disorder merit. The congenital states and their post-congenital possibilities are, to a very limited degree, recognized in the embryonic and reversionary explanations of cancer and malignant growth. To a still more limited degree, developmental pathology is recognized in hematology, since pernicious anaemia is, by leading pathologists, considered a reversion to embryogenic bud states. The alienists have long regarded many of the psychoses as expressions of arrests of cerebral development or of its post-congenital possibilities. The same is true of the so-called hereditary neuroses and psychoses. The other organ states have been less regarded, although both the gynecologists and the genito-urinary surgeons have shown tendencies to take the developmental pathology of these into account in dealing with the origin and consequences of morbid conditions.

The two great phases of developmental pathology have, however, not been used to the degree they should be as guides in the analysis of symptoms and consequences. While conditions in reversion have been considered to some extent, those occurring in phylogeny (race development) have not been separated from those occurring in ontogeny (development of the individual man). Ontogeny does not repeat all the steps of phylogeny, but assumes the essential characters of the race rather quickly. Very frequently the lower phases of phylogeny are, therefore, represented by potentialities capable cf development, rather than by the structures themselves.

Developmental pathology, then, may be regarded as the domain of pathology which deals with departures of structures and organs from the normal along the line of arrests of fetal evolution, either in structure or in the biochemic states underlying functions or potentialities of development at given periods of growth. Atrophies, with or without resultant hypertrophies, and *vice versa* are underlain by its laws.

The general trend has resulted in a working hypothesis compatible with all pathologic phenomena of all the structures of the body, but more especially of the head, face, nose, jaws and teeth, since they are more easily recognized. With this as a guide, the student can readily study the pathologic details of any structure of the body.

To comprehend the pathology of these structures, the laws of phylogeny must be understood. Phylogeny is that process by which an individ-

ual or structure is transformed from a lower to a higher type. Man is still undergoing evolution. His structures are continually changing to suit environment. The master hand is adding a little here and taking away a little there, to adjust him to new conditions as they arise in the world. This process, which has been going on ever since man appeared, is still in progress.

Degeneration is a gradual decline of the structure in type. While the changes pertaining to evolution are in progress, man suffers more or less from his ignorance of the laws governing them, the proper understanding and strict observance of which would banish disease from the earth. His ignorance and consequent failure to re-adjust himself to changing conditions, clog the wheels of evolutional progress and bring about suffering and misery. Not only so, but during the progress of evolutional changes, various extrinsic obstacles are placed in his way, which not only hinder progress but cause degeneration, in type, of his structures. These obstacles consist in parental excesses, resulting in neurasthenia, intrauterine infections from parent to fetus and eruptive diseases of the child.

In man's ontogeny, phylogeny and degeneration go hand in hand. An organ or structure remains with man if, and so long as, it develops or aids in the formation of a new organ. The brain is an apt illustration. Degeneration of an organ or group of organs consists in a gradual restriction or disuse of structures, and their final obliteration or disappearance. The muscles of the ear, the vermiform appendix, the little toe, the false ribs, the pineal eye, and especially the face, including the nose, jaws and teeth, are peculiarly involved in this process.

Progression can take place in the struggle for existence only through general development at the expense of disused organs. The structures of man are influenced greatly by environment. If he remains in a savage condition, generation after generation, his surroundings being the same, he will retain, as a rule, certain fixed conditions of structure. Thus, his brain will not develop, but owing to the retention of the primitive use of his jaws in masticating coarse food, etc., these will retain the size and strength of primitive life. On the other hand, if he abandon the savage life, develop his brain, and is not forced to masticate food, his jaws and teeth atrophy. A marked example of this theory in this country is the evolution of the negro in the past two hundred and fifty years from a dolichocephalic to a mesaticephalic head, and from a prognathous to an orthognathous jaw. Man, in his development from the lowest vertebrate, passes through all the vertebrate stages from the fish and reptile to bird and mammal.

This phraseology is used throughout the entire work, since it simplifies

and makes clear the various stages of man's development. This, however, is not strictly scientific. The terms ichthyopsidae, sauropsidae and mammal are more to the point, for the reason that the terms denote clearly the relationship resultant on the place in the scale of life. The bird, for example, while related in physiology to the mammal, is otherwise an aberrant reptile. Bird and mammal evolve from the generalized type conveyed by the term sauropsidae and not from each other as ordinary phraseology implies. Human embryologic relationships are to the generalized type, not to either bird or reptile. Lower in embryogeny, human type is related to the generalized type, ichthyopsidae, not to either specialized fish or specialized frog.

In his flight from cell to fully developed compound animal, man at the present period of his evolution has, as a result of a loss in explosive force, developed a nervous system. How well he accomplishes this development depends upon brain health. The brain of man develops first, to preside over the development of the other structures. If the brain be normal the structures of the body will develop normal; on the other hand, if from any cause the brain is abnormally developed, unstable or defective, the structures of the body become abnormal. When arrests of the brain occur different classes of degenerates result.

The structures of the nose and cavities of the face display much abnormality because of excessive and arrested development due to their transitory nature and to an unstable nervous system.

In the development of man from the primitive cell, periods of stress constituting new environment occur. Those which occur during development are called periods of evolution, and those after maturity, periods of involution. At these periods of stress, development of the nervous system may be strained, producing arrests of development or degeneration.

Structures undergoing arrests or degenerations are, because of lessened blood supply, more liable to disease than structures which are evolving higher. Marked illustrations of this may be found in irregularities of the teeth and disharmony in jaw development where the teeth are not being lost fast enough for the receding jaws. Interstitial gingivitis and decay are natural methods of hastening the process.

Arrests which occur at any period along the line of development account for all the so-called deformities of the body, which are reversions simulating some features of the lower animals, characteristic of fetal stages through which man has passed. No structures of the body are so prone to these arrests or degenerations as the face, nose, jaws, and teeth, since they are continuous in the line of evolution and are governed by the law of economy of growth in the struggle for existence between organs. This struggle for existence between organs takes place among the animals

as well as man. Wild animals in captivity and other animals through domestication (change of environment and food) have changes in structures similar to that of man.

States normal in lower animals have become abnormal in man. This is of necessity modified by the increasing complexity of ontogeny or individual development in man as affecting phylogeny or race development. Not only are structures affected by these elements, but functions are likewise so modified without underlying structural change. Uric acid excretion, for example, normal in the sauropsidae (birds and reptiles) has become abnormal in man. Its secretion by mammals is, as Fothergill shows, an abnormality with serious consequences. What is true of uric acid is likewise true of other products of suboxidation and imperfect elimination, like indican and excessive acid. The presence of these clogs, like clinkers, the working of the structures, and acts in a peculiar vicious circle to increase the conditions which produce them.

DEVELOPMENTAL PATHOLOGY

A STUDY IN DEGENERATIVE EVOLUTION

CHAPTER I

NATURE OF LIVING BEINGS

Cells

THE bodies of living beings are made up of small particles of living matter called cells, together with a variable amount of non-living matter. The non-living matter comprises either the particles which are cast from the living cells as a result of their activity and those particles which have been taken into the body to further the cell activity.

The activities of the living matter, which distinguish it from non-living matter, may be summed up as follows:

1. Living matter is able to take from its surroundings non-living matter and change it so as to serve its own needs.

2. Some of this matter it transforms, so that it possesses the properties of living matter. The matter is then said to be assimilated. The activities of a cell are attended by a destruction of its substance. The assimilated matter serves to replace that which is destroyed in consequence of cell activity. If the matter assimilated exceeds that destroyed, the amount of living matter increases and the cell grows.

3. The cell, having arrived at a certain age or size, is able to give rise to new cells by a process termed reproduction.

4. The cell exhibits the phenomena of spontaneous movement.

5. It is excitable (reacts to stimuli).

6. It gives off heat.

In some species, the individual organism consists of a single cell, which in itself is a complete and perfect organism. Such a cell has the various powers of assimilation, of protecting itself against the external world, and of reproducing its kind, developed to an equal degree. Such organisms are said to be unicellular.

Other organisms consist of many cells grouped together. Of this class of organisms, some are of so simple a structure that there appears to be no difference of form or function between the different cells. On the other hand, the conditions for the chemical changes necessary to the digestion

of food are more favorable in the interior of the organism, and thus the higher animals and plants come to be composed of differentiated cells that have developed, some one function, some another, to a high degree, while holding the other functions in relative abeyance. A sort of economy of effort, a division of labor is thus set up. Such organisms are organized multicellular beings. They are not haphazard collections of cells, but in each individual the various groups of cells constitute a single organ in which the functions of the various cells are highly specialized, and all are under the control of a single governing power which moderates or stimulates the actions of each cell, co-ordinating them in such a way as to secure the welfare of the organism as a whole.

In such a differentiated organism, the power of the individual cells to move is greatly restricted, and none of them is able, for more than a short time, to maintain existence apart from the other cells of the body. In nearly all the cells, the power of reproduction is greatly limited. One class of cells, however, possesses the power, under proper circumstances, of reproducing the entire body. These are the germ cells of the male and female respectively.

Structure of the Cell

With the low power of the microscope, three parts of the cell (Fig. 1)

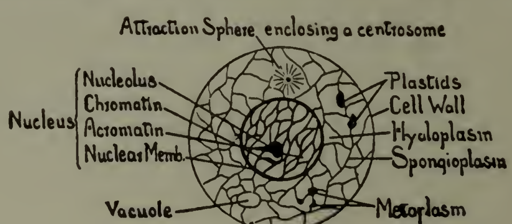


FIGURE 1
Diagram of a cell highly magnified (Shute).

can be distinguished; an outer part, more dense than the interior, sometimes sharply differentiated as a cell wall; an intermediate portion, known as protoplasm; and a central body, called the nucleus. With a somewhat higher magnification, a smaller body is seen inside the nucleus, which is known as the nucleolus.

When carefully examined, the structure of the cell is found to be much more complex. The protoplasm contains numerous small bodies which are known as plastids, and believed by some to be the true physiologic

units. The protoplasm itself possesses a spongy structure known as spongioplasm, the meshes of which are filled with a fluid called hyaloplasm.

The Nucleus likewise exhibits a complicated structure. Near one side is a body known as the centrosome, from which radiate strands constituting the centrosphere. The nucleus also contains a smaller body called the nucleolus. Chemically, the nucleus is found to consist of two substances—chromatin, so-called because it is colored by certain stains, and linin or achromatin, which is not colored by staining agents. The chromatin is closely associated with another non-staining substance known as plastin.

In tissue cells, the nucleoli consist only of plastin. The centrosome is often indistinguishable, but is always present and appears to be specially related to the function of division of the cells (mitosis).

The nucleus is the controlling and vivifying part of the cell. While the proptoplasm, separated from the nucleus, may exhibit for a time the peculiar properties of living matter, it is incapable of continued existence. It soon ceases to live and becomes subject to decay and decomposition.

The Function of the Nucleus includes not only the control of nutrition, but also the processes of reproduction. From what we have learned of the preparation of the chromatin in the maturation of the ovum and sperm, it has been assumed that the chromatin threads are not only the active factors in the development of the embryo, but are also the bearers of the hereditary tendencies of the cell. Through the germ cells are transmitted the accumulated experiences of the race, as shown in the development of the different tissues, and in the continuation of those peculiarities known as heredity and instinct.

The Development of the Human Body from a new cell produced by the union of the male sperm cell with the female ovum is a process of evolution consisting in continued multiplication and differentiation of the cells into tissues and organs. The changes thus effected form a continuous process, intelligently directed to the formation of a human body similar to that from which the original cells sprang. It is believed by most biologists that this individual evolution is merely a repetition of the series of changes through which the race has passed in its evolution from a remote unicellular ancestor, through vertebrate forms, from fish to reptile, and from bird to mammal, up to its present status.

Division of Cells

The simplest process of reproduction is by the sheer division of a cell into two or more similar cells. It is in this way that the tissues grow, and this is the most frequent method of reproduction among the simplest

forms of animals. The usual mode of division of cells is known as mitosis. In this process, the first event is the migration of the centrosome into the protoplasm where it takes up a position close to the nuclear wall. The centrosome then divides into two new bodies, which separate so as to be at opposite sides of the nucleus. The chromatin cords arrange themselves in the form of a spindle, with the two new centrosomes at the respective poles. The chromosomes then divide into double their original number, half attaching themselves to one centrosome and half to the other, and these sets separate so that two new nuclei are formed. Meanwhile, the protoplasm separates into two parts corresponding to the new nuclei and the formation of two new cells is completed. This process may be repeated again and again, so that a large number of cells are formed from a single parent.

Cells may also reproduce themselves by budding, a process essentially similar to that of mitosis, except that, instead of the chromatin spindle formed in indirect or mitotic division, the nuclear fragments are separated, as is the cytoplasm, by simple fission.

Independent Activity in a unicellular organism is well illustrated by the amoeba, (Fig. 2), a creature representative of the simplest form of

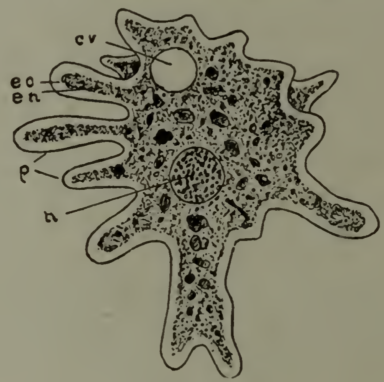


Figure 2
Amoeba proteus (Shute). *n*, nucleus; *c v*, contractile vesicle; *e c*, ectoplasm; *e n*, endoplasm; *p*, pseudopodia.

animal life. It is composed solely of naked protoplasm. Its outer, firmer and transparent portion is known as the ectoplasm (ec), while the inner (which is granular and more fluid) is called the endoplasm (en). As the animal changes its shape, these inner particles or endoplasm move and graduate, without apparent union, into the ectoplasm.

On the outer edge of the endoplasm and attached to the inner surface of the ectoplasm, a nucleus (n) can be more or less distinctly seen. It has

the appearance of a bladder-like cavity surrounding a globular nucleolus. A contractile vacuole (cv) is also located in the endoplasm. The animal thrusts out projections called pseudopodia or false feet, which sometimes consist of ectoplasm, but oftentimes the endoplasm is extended into it so that granules can be seen moving from the center into the false feet and *vice versa.* In this manner, the animal's locomotion is performed as a sort of creeping. Thus the Amoeba finds those other one-celled Desmids and Diatoms upon which it feeds. The Amoeba approaches its food, and by means of its pseudopodial movement, flows around and encloses its prey within its protoplasm where assimilation takes place. The indigestible portions are then cast off. No apparent break can be found in the ectoplasm after the animal has forced its prey through it. This action is analogous to that of the leucocytes in destroying the poisons in the blood. This little creature is found in ponds and streams during the summer months. When resting, it is nearly round, but in motion it is flat upon one side, while the other is extended. There is no egg stage. Reproduction is accomplished by a mitosis (Fig. 3), hence a new Amoeba is like the full grown parent, except as to size.

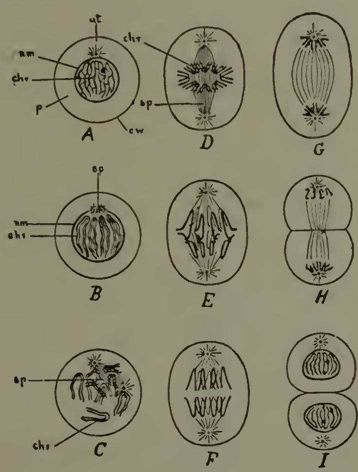


FIGURE 3

Diagram illustrating mitosis (Shute). *A,* the cell commencing activity; *B, C, D,* phases in the formation of the spindle and chromatin loops or V's, also showing that the mother V's have split into daughter V's; *D,* the chromatin loops forming the equatorial plate, *chr*; *E, F, G,* separation of the daughter loops (daughter chromosomes) and their passage towards the poles of the spindle, thus forming daughter nuclei; *H, I,* division of the protoplasm so as to form two daughter cells; *at,* attraction sphere enclosing a centrosome; *n m,* nuclear membrane; *chr,* chromatin threads; *p,* protoplasm; *c w,* cell wall; *sp,* spindle.

The Human Ovum

All the cells of the human body are produced by the repeated subdivision and differentiation of the germ cells from which the individual takes its origin.

The Human Ovum is typically multicellular, small (about one-fifth of a millimeter in diameter) and globular. It is formed within the female sexual gland, or ovary, where it passes through all stages of development, from the imperfect progressive changes of its early condition to a partially complete maturation, before being liberated. It is enclosed in a protecting sac of thin membrane called the *zona pellucida*. The ovum consists of three substances, the yolk or vitellus, a partially fluid protoplasm, an active protoplasm or oöplasm, and the nutritive portion or deutoplasm. The full formation of the ovum is accomplished by throwing out one part of the chromosomes. To accomplish this, the maternal nucleus approaches the protoplastic peripheral surface (Fig 4 A) loses its limiting membrane, and by mitotic division two daughter nuclei appear, known as the polar

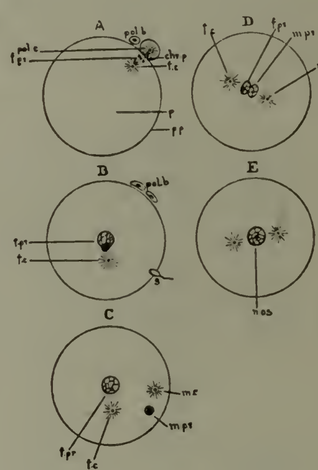


Figure 4
Diagram illustrating the maturation and fertilization of the human ovum (Shute). *A*, one polar body is formed and a second is in process of formation; *B*, both polar bodies are formed and a spermatozoid is penetrating the ovum; *C* and *D* represent the approach of the male pronucleus towards the female pronucleus; *E*, indicates the amalgamation of the two pronuclei to form the nucleus of the oösperm (segmentation nucleus); *pol. b*, polar bodies; pol. *c*, centrosome of the polar body; *chr. p*, chromatin of the polar body; *f pr*, female pronucleus; *p*, protoplasm; *p p*, peripheral protoplasm (but not cell wall); *f c*, female centrosome; *m c*, male centrosome; *m pr*, male pronucleus; *n, os*, nucleus of the oösperm (first stage of a human being).

bodies, Fig. 4 A. B. pol. b. These bodies are seen as small deeply stained cells in the space under the *zona pellucida*.

The remaining cellular material, after the formation of the polar bodies, is gathered within a new nucleus, leaning toward the center within the egg, and is called the female pronucleus or egg nucleus. Fig. 4 B. f. pr. This nucleus differs from the nucleus of all other body cells in that it only contains half as many chromosomes (hereditary threads).

The flagellate sexual cell of the male, or spermatozoon, corresponds to the female ovum. It also contains only half the number of chromosomes.

Fertilization

FERTILIZATION is the union of the male and female elements by the penetration of the former into the latter. Impregnation takes place usually in the upper third of the oviduct, but any part of the genital tract may become the site of the union.

SPERMATOZOA consist of three parts, head, tail and intermediate portion, and are not unlike a tadpole in appearance, Fig. 5. The head, triangular and flat from side to side, contains a certain amount of chromatin. By virtue of the rapid movement of their tails, spermatozoa, according to Henle, can travel one centimeter in three minutes.

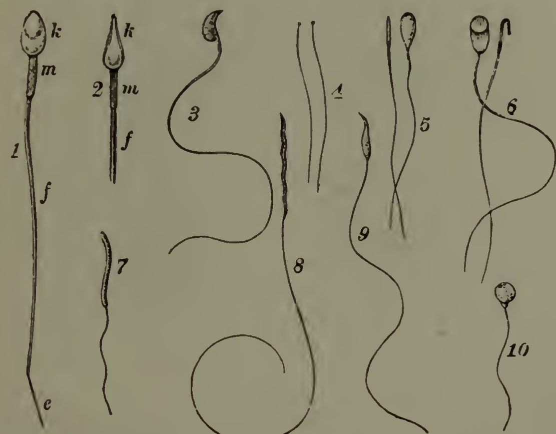


FIGURE 5

Spermatozoa (Landois and Stirling). 1, human (X 600), the head seen from the side; 2, on edge; *k*, head; *m*, middle piece; *f*, tail; *e*, terminal filament; 3, from the mouse; 4, bothriocephalus latus; 5, deer; 6, mole; 7, green woodpecker; 8, black swan; 9, from a cross between a goldfinch (M) and a canary (F); 10, from cobitis.

NORMAL HUMAN IMPREGNATION is accomplished by a single seminal element, Fig. 4 B. s. After the penetration of the ovum by a single male

element, the vitelline membrane immediately thickens to prevent the entrance of additional spermatozoa. The two pronuclei then form a single nucleus, Fig. 4 E. n. os.

The head of the spermatozoon alone enters the ovum; the tail, failing to penetrate the vitelline membrane, is soon lost. Thus nothing remains of the sperm but a small spindle-shaped mass, the male pronucleus, which soon makes its way to the center of the ovum and fuses with the female pronucleus to form the segmentation nucleus. The fertilized ovum, or oösperm, now contains the normal amount of chromosome material, the

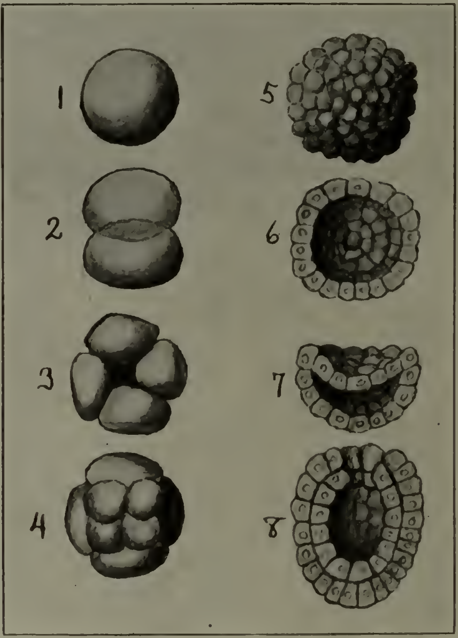


FIGURE 6
Early stages of segmentation of the primitive cell (Van Beneden). 1, the fertilized ovum; 2, two segmentation spheres of equal size; 3, the segmentation of the two cells into four; 4, the four cells divided into eight; 5, the morula stage; 6, section through blastula showing a single layer of cells surrounding segmentation cavity; 7, beginning of invagination of entoblastic area; 8, complete gastrula. The inner layer (hypoblast), the outer layer (epiblast), the opening represents the mouth of the cavity.

number of chromosomes dimished by the loss of the polar bodies being now made up by the addition of the male pronucleus.

The cell produced by this union is the first existing stage of man, who begins his life cycle as a unicellular animal.

Segmentation of the Ovum

The result of the union of the male and female pronuclei is the formation of a nucleus which, undergoing division by mitosis, forms two cells. These in turn divide into four, and so on, until a large mass of small cells is formed (Fig. 6), spherical in shape, those near the surface projecting in such a manner as to resemble the mulberry or morula, Fig. 6, No. 5. In this stage, man is analogous to the protozoans. As growth proceeds, the morula cells arrange themselves in a regular layer at the periphery so that the embryo is not unlike a hollow sphere. This is termed the blastula stage, Fig. 6, No. 6. The next stage in development varies in different animals. In some animals, the blastula is found pushed in on one side, Fig. 6, No. 7. Typical gastrulation of the lower animals does not occur in the higher mammals. The fluid surrounding the morula mass forces the cells to the periphery, giving rise to a vesicular structure consisting

FIGURE 7
Blastodermic vesicle of rabbit (Van Beneden). The upper dotted line represents the zona pellucida. The line below, the primitive ectoderm; below this, the internal cell mass. The space, the cavity of vesicle. The lower line, albuminous envelope.

of a single layer of cells, which surrounds the cavity filled with fluid, the segmentation cavity. This is called the blastodermic vesicle, Fig. 7, which has been demonstrated by Beneden in the rabbit. The formation of the blastodermic vesicle has not been observed in the human ovum. Since, however, it has been demonstrated in the ova of many animals, there is little doubt that it is the method of formation of cells in the ova of all mammals. This process of cell division is known as segmentation and it is common to all animals and plants.

The nutritive yolk elements of human and mammalian ova are scanty but uniformly distributed throughout the vitellus. This uniform distri-

bution is known as homolecithal. In fish, reptiles and birds, on the other hand, the yolk is not uniformly distributed, but is collected at one pole. This type of segmentation is known as telolecthal.

Differentiation of Cells

In many cells, the protoplasm, or the exterior of the cells, contains peculiar substances, formed from the protoplasm, which are called metaplasm. These substances vary in different cases and lead to the differentiation of the cells. The collection of cells of one kind into a contiguous grouping leads to the formation of tissues, the methodical arrangement of which results in the purposeful production of organs and of the skeletal structure.

The earliest division of the cells is into three germinal layers (Fig. 8), the epiblast (ectoderm), the hypoblast (endoderm) and mesoblast (meso-

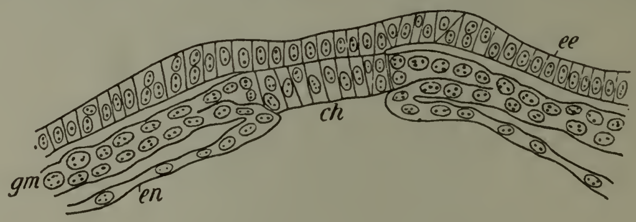


FIGURE 8
Transverse section through the embryonic disk of a rabbit (Van Beneden). *ch*, chorda endoderm; *ee*, ectoderm; *en*, endoderm; *gm*, gastral mesoderm.

derm). The cells of the epiblast form a superficial layer known as epithelium, as a result of many and complicated embryonal infoldings. Other cells of the epiblast become entirely enclosed in the interior of the body and form the brain, the spinal cord and nerves.

THE HYPOBLAST also consists of epithelium which lines the digestive and respiratory tracts. Some of the epithelium, both of the epiblast and the hypoblast, sinks below the surface, still retaining a communication with the exterior and forms glandular epithelium (Fig 9.)

The simplest epithelium is that which serves for the protection of the body, the stratified squamous type, the outer layers of which become degenerated, flattened, hardened and scale-like and thus form a more or less protective armour for the more delicate underlying tissues. From such epithelium are developed the appendages (the hair, nails, teeth, horns, hoofs, feathers, etc.). In the cavities of the body which communicate with the exterior, as the mouth, nostrils, external genitalia, etc., the

protective epithelium produces mucus which serves to moisten the surfaces and carry away injurious substances. The epithelium of the air passages is provided with hair-like moving appendages called ciliae, which, with a rythmic, wave-like motion, serve to bring foreign bodies to the surface. Glands possess a specialized epithelium whose function it is to secrete the so-called enzymes, or digestive juices and fluids, necessary for the preparation and assimilation of food, and for the economy of the body.

Specialized epithelium in the skin, the so-called sensory end-organs, becomes connected with nerve fibres and serves for the transmission of sensory impressions of pressure, pain, heat and cold.

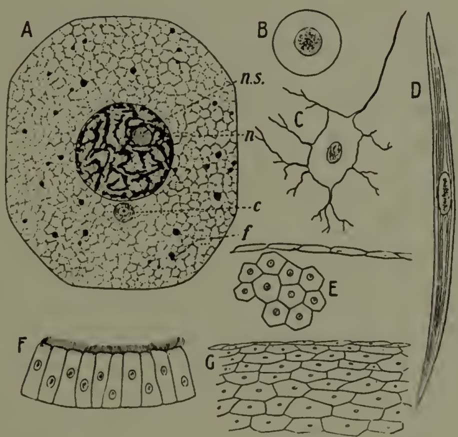


FIGURE 9

Different types of cells composing the body of a highly developed animal (Animal Studies, Jordan, Kellogg and Heath). *A*, cell; *f*, food materials; *n*, nucleus; *B*, blood cell; *C*, nerve cell; with small part of its fiber; *D*, muscle fiber; *E*, cells lining the body cavity; *F*, lining of the windpipe; *G*, section through the skin. Highly magnified.

The cells of the nervous system are highly differentiated and serve for the transmission of impulses of both a sensory and a motor character. Each cell possesses long processes which arborize with the processes of other distant cells and so form a union by which impulses are relayed from the periphery to the higher centers and from the higher centers back to the periphery.

THE MESOBLASTIC cells are modified in various ways. The simplest form is the connective tissue cells, long fibres of metaplasm, which are woven into membranes, tendons, the sheaths of muscles and the supporting

structure of the various organs. In many parts of the body, these cells become filled with fat, giving rise to the adipose tissue. Other cells of the mesoblastic layer give rise to a peculiar metaplastic matrix cartilage, in which they lie scattered here and there. Moreover, this cartilage may become further differentiated, take on osteoblasts, become impregnated with lime salts, and form bone. Another peculiar production is the formation of layers of protoplasmic material containing hemoglobin and albuminous substance, known as myosin. These structures constitute the striated, or voluntary, and the unstriated, or involuntary, muscles, and are under the direct control of the central nervous system through their nervous connections. In the bone marrow and the blood vessels the cells remain free, and some of them, containing hemoglobin, lose their nuclei and serve for the conveyance of oxygen. The others remain colorless and retain their nuclei and are known as the leucocytes, or white blood corpuscles.

In the human body, the white cells of the blood act as unicellullar organisms. They possess the power of movement and some of them are capable of seizing, engulfing and digesting foreign bodies, such as bacteria, in a manner similar to that of Amoeba Proteus. As a further illustration of the capabilities of cells in the body, we may refer to the action of the osteoblasts and osteoclasts. These cells are naked pieces of protoplasm, the osteoclasts being much the larger of the two. The osteoblasts and osteoclasts have to do with some of the most interesting phenomena of many growing animals. The osteoblasts have the power of constructing the bones of animals in the same way as the foraminifera have the power of forming complex aggregations of limestone shells.

The Osteoblasts are bone formers, and the osteoclasts are bone destroyers. It is a striking fact that these small specks of living jelly, the osteoclasts, should have the power of destroying hard tissue like bone. They have power, by virtue of their wonderful chemical processes, to liquefy and absorb, and by these means destroy ivory pegs that are driven into living bone. The osteoclasts are the agents which destroy the roots of the teeth so that the crowns of the temporary teeth are shed and the way paved for the appearance of the permanent teeth. The growth and shedding of the antlers of the deer furnish a good example of the wonderful activity of these little osteoblasts and osteoclasts. While these antlers are growing they are covered with a delicate skin, technically called "velvet." The blood circulating through it keeps this velvet warm and sensitive. The blood contains thousands of living osteoblasts that are working together under some mysterious directing or co-ordinating agency, to build up these splendid beams, tynes and snags that compose the antlers. The building of the antlers by these little agents continues through the

spring and summer. In the fall, the osteoblasts cease their activity and die; the delicate, sensitive velvet dries and peels off, leaving the dead, hard bony substance exposed and the horns then become weapons for fighting. At this season, the stags challenge one another to single combat, the hind standing timidly by to be taken by the victor as his mate. After the loves and battles of fall are over, and the antlers are no longer of use, they are shed. This shedding is brought about by means of the bone destroyers, or jelly-like cells, called osteoclasts.

While man and animals differ in the mode of gastrulation, the common point essential to all is the formation of a double cellular membrane. These membranes, which are derived from the early blastodermic vesicle, are the outer, called the epiblast or ectoderm, and the inner, the hypoblast or endoderm. These two are the primary germinal layers; a little later a third layer is added between them, known as the mesoblast. These three cellular membranes are the base of all the complex human tissues and organs.

The following tissues of the body are derived from each of these blastodermic layers:—

From the Epiblast—The epithelium of the outer surface of the body, including that of the conjunctiva and anterior surface of the cornae, the external auditory canal, together with the epithelial appendages of the skin, as hair, nails, sebaceous and sweat glands (including the involuntary muscle of the latter). The epithelium of the nasal tract, with its glands, as well as of the cavities communicating therewith. The epithelium of the mouth and of the salivary and other glands opening into the oral cavity. The enamel of the teeth. The tissues of the nervous system. The retina; the crystalline lens and, perhaps, part of the vitreous humor. The epithelium of the membraneous labyrinth. The epithelium of the pituitary and pineal bodies.

From the Mesoblast—The connective tissues, including areolar tissue, tendon, cartilage, bone, dentine of the teeth. The muscular tissues, except that of the sweat-glands and dilator pupillae. The tissues of the vascular and lymphatic systems, including their endothelium and circulating cells. The sexual glands and their excretory passages, as far as the termination of the ejaculatory ducts and vagina. The kidney and ureter.

From the Hypoblast—The epithelium of the digestive tract with that of all glandular appendages, except those portions derived from epiblastic origin at the beginning (oral cavity) and termination of the tube. The epithelium of the respiratory tract. The epithelium of the urinary bladder and urethra. The epithelium of the thyroid and thymus bodies, the atrophic primary epithelium of the latter being represented by Hassall's corpuscles.

Summary

Livings beings are made up of cells possessing the powers of (a) metabolism; (b) assimilation and growth; (c) reproduction; (d) spontaneous movement; (e) excitability; (f) heat production. Organisms may be, 1. unicellular; 2. multicellular but undifferentiated; 3. multicellular and differentiated.

Structure of the Cell. The cell consists of (a) cell wall; (b) protoplasm containing, 1, plastids and itself consisting of 2, spongioplasm and 3, hyaloplasm; (c) nucleus containing 1, centrosome; 2, chromatin beads on 3, linin threads (the bearers of hereditary tendencies), and 4, nucleolus consisting only of plastin. Functions of the nucleus are (a) control of nutrition, and (b) of reproduction. Evolution of the cell proceeds by multiplication and differentiation into specialized cells whose arrangement forms the various tissues and organs.

Process of Mitosis. Migration of centrosome. Division into polar bodies. Doubling of chromosomes. Separation of chromosomes and attachment to two centrosomes with formation of two new nuclei. Division of protoplasm forming two new cells. Cells also multiply by budding.

The amoeba is a typical unicellular organism consisting of ectoplasm, endoplasm, nucleus, vacuole and pseudopodia.

The Human Ovum consists of a cell which has undergone partial mitosis, having cast off half of its chromosomes. The spermatozoon is a flagellate cell also containing only half the regular number of chromosomes. Fertilization takes place by the penetration of the spermatozoon into the ovum with a union of the two pronuclei to form a single nucleus.

Segmentation of the Ovum results in morula and gastrula-like forms which eventually become modified so as to form two primary germinal layers, the epiblast and the hypoblast, between which is developed a third layer, the mesoblast. From these three layers, by further differentiation and segregation, are derived the various tissues, namely, epithelium, nerve-cells, connective tissue, cartilage, bone cells, muscle fibres, endothelium, blood cells, osteoblasts (bone builders) and osteoclasts (bone destroyers). Out of these tissues, again, are built up the various organs of the body. All of this differentiation and segregation is carried on under the controlling influence of a central governing power which co-ordinates the parts for the welfare of the whole.

Chapter II

DEVELOPMENT OF MAN

THE development of man is to be considered under two aspects: First: The development of species from an undifferentiated unicellular animal to the highly specialized creature now inhabiting the earth, is known as PHYLOGENY. Second: The development of the individual in one generation from the single cell to the adult form is called ONTOGENY.

Our knowledge of phylogeny is largely a matter of reasoning from the observed relations of animals to each other and from the order in which they have appeared on the globe.

The two processes correspond so closely that it has become almost an axion of biology that the individual, in its development, recapitulates the stages and follows the order of the development of the species. In this chapter both divisions will be considered under one head.

In the preceding chapter, it was shown that every living being begins life from a cell, or egg, by the union of two germ cells, one from the male and the other from the female. This fertilized cell, and its future development, forms a new being of the same species as the parent. Fig 10 illustrates

FIGURE 10
The germ cell or egg of vertebrates (modified from Animal Studies, Jordan, Kellogg and Heath). 1, fish; 2, reptile (frog); 3, bird; 4, mammal (human).

the germ cell, or egg, of vertebrates, namely, a fish, reptile, bird and mammal, or human.

From the morula stage on, there are three important factors in development: first, the differentiation of cells which form the different animal tissues; second, their arrangement and grouping into organs or body parts;

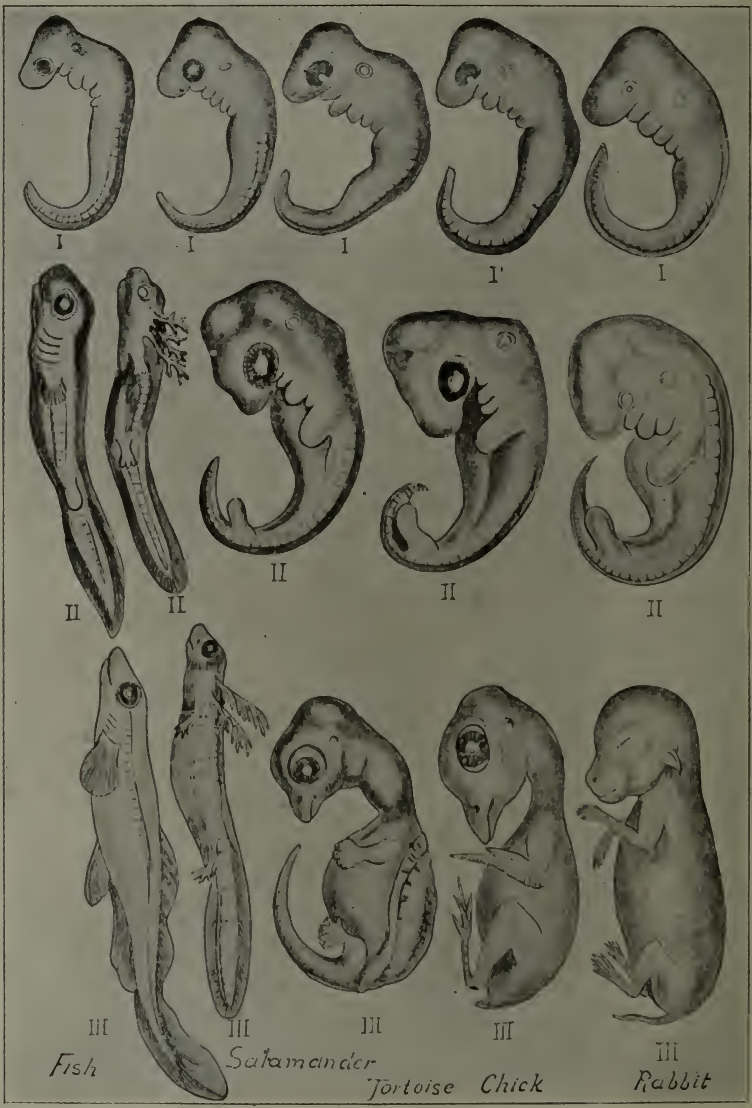


FIGURE 11
Different vertebrate animals in successive embryonic stages (Haeckel). I, first or earliest of the stages figured; II, second of the stages; III, third or latest of the stages.

and third, the development of these organs and body parts into the form characterizing the species to which the developing creature belongs. From the primitive indistinguishable cells of the blastoderm, development leads to certain cell type of muscular, bony and nerve tissue; from this generalized condition, the embryo, in its early developmental stages, passes to the special condition of the full grown animal. All many-celled animals are alike in the early, or first stages, of their formation, that is to say, each body is composed of a single cell. This similarity continues through several stages, when the embryos begin to differ and each assumes its own special type. This divergence of the embryos in the course of their development is aptly illustrated in Fig 11, which shows embryos from fish, reptile, bird and mammal. In the first stages of embryonic development no difference can be detected, in the second the divergence is more noticeable, while in the third there is nothing in common.

Illustration of Phylogenetic Development. A good example of the way in which an animal in its individual development passes from the shape of an animal of a lower order to that of one of a higher order is seen in the development of an insect. The butterfly (Fig. 12), as is well

Figure 12
The transformation of the butterfly from the egg (the primitive cell), (modified from Animal Studies, Jordan, Kellogg and Heath). 1, the primitive cell; 2, the larva; 3, the pupa; 4, the completely formed butterfly.

known, lays an egg (1) which is a unicellular animal, a protozoan. This egg divides into two cells, these two into four, the four into eight, the eight into sixteen and so on (Fig. 6) and assumes the form of a multicellular animal of very simple structure. The changes which take place in the cells represent different stages in the development of the animal which is

to be produced. In this instance, it then develops into a being having the form and structure of a worm (2). This worm, known as a caterpillar, emerges from the egg and pursues, for a time, an existence similar to that of the worm. It then undergoes a transformation through the chrysalis (3) by which it becomes a member of a higher order or class of insects (4).

Another still more instructive example of development, following the order of ascent from a lower to a higher class and from one order to another in the higher class, is that of the frog (Fig 13), which develops from an egg through the stages described for the caterpillar, but leaves the egg in the form of a fish. Like a fish (1), it breathes by gills, has a two-chambered heart and swims about in water by means of a tail. It has no developed

Figure 13
The evolution of the frog from the tadpole (modified from Animal Studies, Jordan, Kellogg and Heath). 1, tadpole with branching gills; 2, gills absorbed and hind legs have appeared; 3, four legs have appeared and absorption of the tail has begun; 4, complete absorption of the tail and fully developed frog appears.

limbs. It feeds on vegetables. The vertebrae are biconcave as in fishes. Up to this point, the development of the fish and of the frog are very much alike, but the fish stops here and remains without limbs or lungs, breathing always by gills. In the frog, on the other hand, limbs begin to bud out and the lungs begin to develop and the external gills soon disappear, although the internal ones persist for a while longer. The creature can now

breathe both air and water. In this stage it resembles an amphibian of a low order, called the siren. Both the frog and the siren pass through the fish stage, but the siren stops at the next stage, retaining its tail and its gills, while the frog loses both. It develops a three chambered heart. Before it has completely lost its tail, it resembles an order of amphibia higher than the siren, to which the triton belongs. In the course of development, both the frog and the triton pass through the fish and siren stage into the triton stage, where the triton stops, while the frog goes on to the complete development of a higher order. The tail is now completely lost and the vertebrae assume the ball and socket type. At this period of transformation from a water to a land animal, hind legs (2) begin to develop through the skin. At a later date the fore-legs (3) develop. Fingers and toes, too, appear. Stretched between them is a web which allows the animal to swim with legs and feet, instead of a tail, as well as to hop about. While this process is occurring on the external surface, internal changes are taking place. The branching external gills are absorbed and lungs are developed from an enlargement and pouching of the walls of the esophagus. Blood vessels, too, develop throughout the structures. This change allows the animal to rise to the surface of the water and float with ease. The new development allows the animal to extract oxygen from both the air and water. He becomes a new being (4) with the change of environment, some of the old structures remain useful and are retained, while others become useless and are discarded. Some of the old structures are modified to adapt themselves to the new environment.

The teeth develop and the animal becomes insectivorous. The diet of the tadpole changes from a vegetable to animal food and the alimentary canal undergoes an entire change in harmony with the new environment. In this development of the frog, two important features are to be noted. First, the animal passes from a lower to a higher type, under the law of evolution, from the class of fishes to that of the amphibia. Second, this development is accomplished by the dwindling and disappearance of some organs and the new development of others. These changes, which take place in evolution, have been interpreted by different scientists in different ways. Thus:

Aristotle called it the law of economy of growth, whereby an organ or structure is lost for the benefit of the organism as a whole; Lucretius showed long ago how the strongest survive and the weak are laid low, or survival of the fittest; Lemarck called it use and disuse of structures; while Darwin, harmonizing these different views, called it natural selection; Roux called it the physiologic struggle for existence between the organs, the cells and protoplasmic molecules of the organism, and Osborn, in the study of animals, termed it the law of compensation.

Phylogeny

Phylogeny is an Evolution of Man as a Race from a unicellular form, like the amoeba, through more and more complex forms that resemble those of the lower animals until it produces the characteristic human form. A strong evidence of the order of this development is seen in the intrauter-

Figure 14
The human embryo in its successive stages corresponding to Haeckel (original). 1, first stage; 2, the second stage; 3, the third, human stage.

ine development of the embryo. The first cell produced by the union of the male and female genital cells (spermatozoon and ovum) multiplies by division until it forms a mass of cells resembling the morula (mulberry-like form), Fig. 6, No. 5. In this state, the embryo resembles a colony of undifferentiated protozoans. The mass then begins to assume shape and is seen to consist of layers of cells somewhat differentiated. So far, the changes are such as we might naturally expect in the formation of a large mass of cells destined to take the human form. The formation of the primordial central system, and the rudimentary spinal column, mark the transition to a vertebrate type, but no one could tell by mere observation whether the embryo was that of a fish, amphibian, sauropsidae (reptile and bird) or mammal; the type is the general one of the vertebrate but not the specific one of any of these divisions.

But now a singular thing occurs. The embryo takes the form of a fish before it passes into that peculiar to the mammalian type. There appears a tail and, especially, gill slits, which indicates an animal fitted for breathing gases dissolved in water, Fig. 11, No. 1. Man then passes from the fish stage through the sauropsidian (reptile and bird) stage into the type characteristic of the mammal, Fig. 11, No. 2. One cannot say, however, from observation of the embryo at this stage whether it is that of the camel, dog, ape or man. It corresponds to the general type of the class, but not to any specific order. As the evolution proceeds, it takes more and more a specific character and terminates in the production of the fully formed human infant, Fig. 11, No. 3.

The embryo of man, therefore, exhibits a similar passage through vertebrate forms resembling the fish, the reptile, the bird, the lower mammal, the lower monkeys, the higher apes, until the fully developed child resembles the lower forms of mankind, Fig. 14.

Like the frog, man accomplishes his development by the disappearance of some features peculiar to the lower forms and by the addition of characteristics belonging to the higher forms. In the case of those structures which disappear, the disappearance is gradual and frequently is not complete, so that structures that were fully developed in the lower forms and served a useful purpose may be represented in man as degenerate or vestigal, that is, of no apparent use.

"The theory of evolution, then" as Shute says, "teaches that this development of man in the course of a few short months, like the development of the frog, is a very condensed and abbreviated epitome of the evolution of mankind from primitive protozoans during the incalculable ages of the past."

The animal world of today may be conceived of as the twigs of a tree of which many have sprung from a common branch, and these common

branches from an earlier one, etc. Just as the leaves, twigs, branches and trunk of a tree have a common origin, viz., the seed that developed into the tree, so all the different species of animals of the present and past are the trunk, branches, twigs and leaves of the "tree of life" and have had a common origin—from a primitive protozoan cell. (See diagram of development, Fig. 15.)

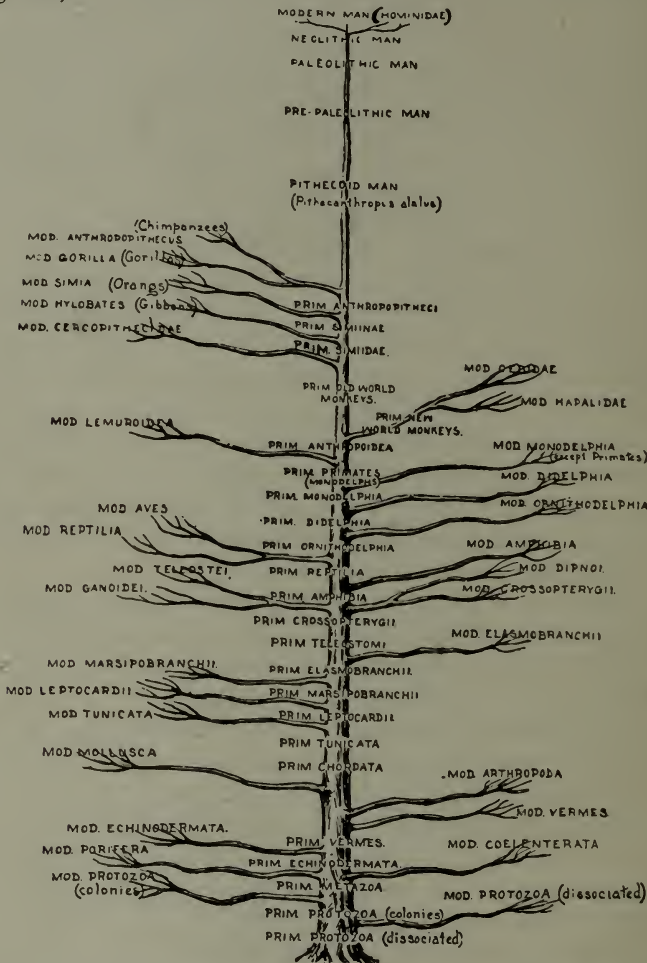


FIGURE 15

Diagram of development (Shute). Portion of the "Tree of Life" showing approximately the relative places of the great groups of animals. The central trunk and primary branches represent primitive (geologic forms); the terminal twigs represent modern forms. Man, like other animals, is a generalized development from the protozoa not from any special type of metazoa. In his development, therefore, he does not repeat all the steps of phylogeny but assumes the essential character of the race very quickly.

When life began as a primitive cell this cell contained potentially all the animal forms that have existed on the globe, just as the fertilized egg contains potentially all the tissues and organs of the adult man.

The ancestors of man and of all the forms that belong to the present class of mammals, at one time belonged to the class of protozoans (simple cell), their successors were metazoa (higher than protozoa, having an ectoderm and endoderm). The successors of these were worms. Some of these worms developed into primitive fishes, and from these some developed into modern fishes, while others became the primitive amphibia (lowest vertebrates which breathe air). From amphibia sprang reptiles, leaving behind some of their kind which remained amphibia and have produced the frogs and toads of today.

From reptiles some passed on to become primitive mammals, (vertebrates whose females have milk-secreting organs). Of these primitive mammals, two preserve certain reptilian peculiarities. They are not warm blooded, like birds and mammals, but have a temperature far lower than these. Both these mammals (the duck-bill and spiny ant eater) lay eggs. In the spiny ant eater, the skin, at the time of egg laying, forms a pouch over the abdominal mammary gland. In this pouch, the eggs are deposited and hatch. This is a connecting link between the reptiles in whom the young are hatched just before exclusion and the pouched mammals (marsupialia). The primitive mammals were of different classes. Some remained almost stationary and their descendants are the marsupials of today, like the kangaroo. Others advanced to become the common ancestors of the monkey and man. These primitive primates had both pithecoid (simian-like) and anthropoid (man-like) characters. Some of these developed the tail to a marked extent and became tailed monkeys; others lost the tail and more and more became beings much like the modern chimpanzee. Some of these lived in trees and retained the use of the feet for grasping, like the gorilla and orang-outang of today. Others, leaving the trees and living on the ground, used the feet for walking the hands more for grasping, and became primitive man. They assumed the upright posture and their bodies became modified in related ways to suit their new mode of life. Particularly, the development of the brain began to dominate the course of evolution and the structure of the body was modified and subordinated, to a certain extent, to that of the dominant central nervous system.

In tracing the descent of man, it must not be supposed that the ancestors of man were altogether like the modern representatives of the primitive forms through which he has passed. The reptile-like ancestors of man were unlike the modern reptiles. They lacked in two respects the characters of modern reptiles. First, they were not specialized in the

manner of modern reptiles. This is well illustrated by Shute in the following passage:

"To illustrate what has occurred at each stage in the evolution of man, pause for a moment to consider that phase of progress represented by the primitive reptilia. If we study the anatomy of the specialized reptiles, birds and monotremes (toothless mammals) of the present, we will find that they have many characters in common. These characters are reptilian. Each class has its own distinctive, specialized peculiarities in addition to its common reptilian characters. The study of the fossils of the rock shows that in the jurassic and cretaceous ages, animals existed that were undoubtedly reptiles, but had also very distinct bird-like characters; also reptiles existed that had distinct monotreme characters. These reptiles came from those of earliest times that were still more generalized. As the ages passed, some of the generalized reptiles (primitive reptiles) lost more and more their reptilian features, and gradually, assumed more and more distinct bird characters until, finally, the highly specialized modern birds ("glorified reptiles") were evolved, as a branch, from the primitive reptiles. So also with the modern reptiles and modern monotremes. They are specialized forms of these general primitive reptiles."

It is not. therefore, correct to say that man is descended from the ape. The ape of today is a specialized descendant of the common ancestor, and man is another specialized form of this common being.

The anthropoid ape, at the early period of life, often presents characters quite unlike those of the adult, Fig. 16. While the young anthropoid is comparatively human, the adult ape is comparatively bestial in character. The young ape has a smooth, globular, head and relatively small face, like man. The profile is more human with little prognathism. The base of the skull is formed in a more human way than in the adult ape. The brain is relatively very much larger than in the adult. In the gorilla, for example, the fetus differs from the adult by having relatively a much larger head, a longer neck, a more slender trunk, shorter thumb and great toe; while the head is more globular, the face less prognathous and the hand more man-like. In nearly all these characters, the fetal gorilla approaches man. The adult male ape rapidly develops into a condition far removed from his early man-like state. The brain becomes relatively very small, the receding skull becomes hideous with huge, bony crests, sharp angles and, on its enormously enlarged facial portions, prominent outstanding superciliary ridges, projecting jaws and receding chin, while the dark, hairy body becomes more bestial in character. The female ape remains midway between the infantile and the adult male condition. So far as man is ape-like, it is infantile rather than the adult form which he resembles. Man, in the course of his life, falls away more and more from the specifically

human type of his early years, but the ape, in the course of his short life, goes very much farther along the road of degradation and premature senility. The ape starts in life with a considerable human endowment, but in the course of life falls far away from it. Man starts in life with a still greater portion of human or ultra human endowment and to less extent falls from it in the adult life, approaching more and more to the

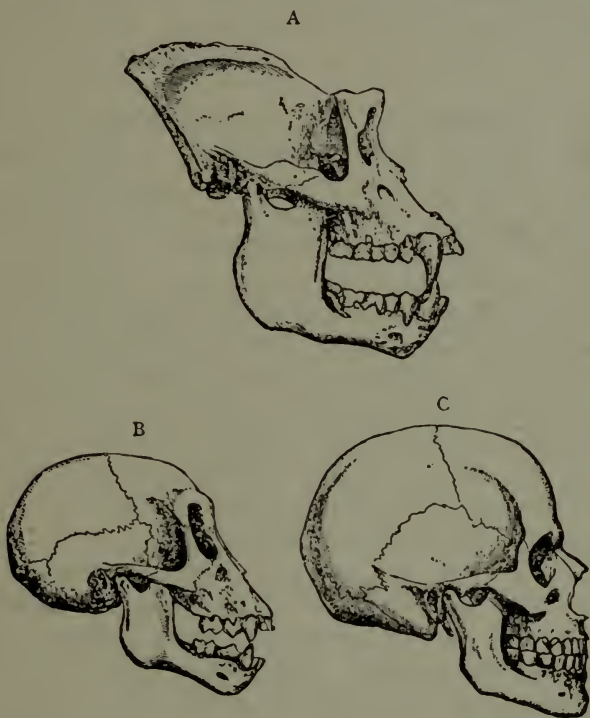


FIGURE 16
Comparison of the skulls of the young and adult gorilla with the human (British Museum Guide to Mammalia). *A*, the skull of an adult gorilla. The degeneration of the brain and skull for the benefit of the jaws and teeth is marked. *B*, skull of a young gorilla. It is at this period that resemblance to the human is most marked. *C*, the skull of an adult man. In his evolution from the lower vertebrates, the jaws and teeth have degenerated for the benefit of the brain. The opposite condition of *A*.

ape. Up to birth, or shortly afterwards in the higher animals, such as the apes and man, there is a rapid and vigorous movement along the line upward in zoologic evolution. A time comes, however, when this fetal or infantile development, ceasing to be upward, is so directed as to answer to the life wants of the particular species. Henceforth and throughout

life there is chiefly a development of lower characters, a slow movement towards degeneration and senility, although one absolutely necessary to insure the preservation and stability of the individual and species.

Fetal evolution, which takes place sheltered from the world, is in an abstractly upward direction. After birth, further development is a concrete adaptation to the environment without regard to upward zoologic movement. The infantile condition in both ape and man is somewhat alike and approximates to the human condition. The adult condition of both, also, tends to be somewhat alike and approximates to the ape-like condition.

The human infant presents, in an exaggerated form, the chief distinctive characteristics of humanity, the large head and brain, the small face, the hairlessness, the delicate bony system. By some strange confusion of thought, this fact is usually ignored and it is assumed that the adult form is more highly developed than the infantile form. From the stand-point of adaptation to environment, the coarse, hairy, large-boned and small-brained gorilla is better fitted to make his way in the world than the delicate offspring, but from a zoologic point of view anything but progress occurs. In man, from about the third year onward, further growth, though an absolutely necessary adaptation to the environment, is, to some extent, growth in degeneration and senility. It is not carried to so low a degree as in the apes, although by it man is, to some extent, brought nearer to the apes. Among the higher human races, the progress toward senility is less marked than among the lower human races. The child of many African races is scarcely, if at all, less intelligent than the European child. The African, as he grows up, however, becomes stupid, obtuse, and his whole social life falls into a state of hide-bound routine. The European retains much of his child-like vivacity. The highest human types represented in typical men of genius are a striking approximation to the child type.

Another character which differentiates the common ancestor from the multitudinous forms of the animal world as we see them today is the plasticity of his organism as compared with theirs. If men were swept from the earth today, there is little reason to suppose that a new human race would develop from the existing animal types. It must be assumed that these primitive ancestors possessed a capability of evolution not to be seen in the ordinary animal types of today.

Summary

The development of man is regarded from the view-point of phylogeny, or the development of the species, and ontogeny, or the development of the individual.

The individual, in his development, recapitulates the stages and follows the order of the development of the species. The ontogeny repeats in abbreviated form, the phylogeny. However, the net tendencies of phylogeny and ontogeny are opposed to each other, phylogeny tending to racial progress, ontogeny to individual adaptation.

The embryo of man passes through forms representing protozoa, metazoa, primitive vertebrates, fish, reptiles, lower mammals, primitive apes and finally man, differentiating itself from each successive species as it develops upward.

As evolution proceeds, useless structures disappear or become rudimentary, and new and useful structures are added. This principle is well illustrated in the evolution of the frog from the tadpole and the butterfly from the caterpillar.

The primitive type from which man and other animals descended had more general characters and a more plastic organism than the forms descended from it.

The fetal and infantile stages approach this common type and represent the racial or phylogenetic development of the species. As the adult stages supervene the phylogenetic influences are overshadowed by the ontogenetic, the organism becoming specialized to meet the life-requirements of the individual, and losing its plasticity, so that further phylogenetic development is stopped.

Hence it is in fetal and child life that phylogeny is best studied; in adult forms, that ontogeny is best represented. Hence also those species in which fetal life and infancy are longest contribute, *ceteris paribus*, most to phylogenetic progress.

Chapter III

DEVELOPMENT OF ORGANS

The Brain

ONE characteristic of development is that each organ pursues the same type of development as the organism considered in the previous chapters. Each organ develops from a single cell. By mitosis, the cell divides and forms a community of cells, which become specialized into particular organs. The organ then undergoes the various changes according to environment from a lower to a higher order, as observed in the invertebrates and vertebrates already described. The intention is to discuss such phylogeny and ontogeny only as have particular bearing upon structures under later discussion. A good example is that of the brain.

The brain, the central nervous organ, presides over development of tissues controlling nourishment to each one, whether a man or his organs shall develop normally or abnormally is thus determined. The phylogeny and ontogeny of it, therefore, interests the student at this time.

The Phylogeny of the Brain

The Brain of Fish. Fig. 17 represents the brain of an average bony fish. It consists of six swellings in a line, one before the other. Beginning

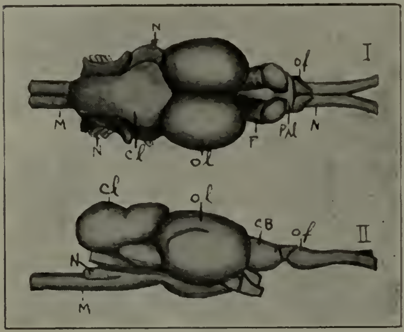


Figure 17
Brain of bony fish (modified from Hertwig's Manual of Zoology, Kingsley). 1, dorsal view; 2, side view; *m*, medulla; *n*, nerves; *cl*, cerebellum; *ol*, optic lobes; *cb*, cerebrum; *of*, olfactory lobes.

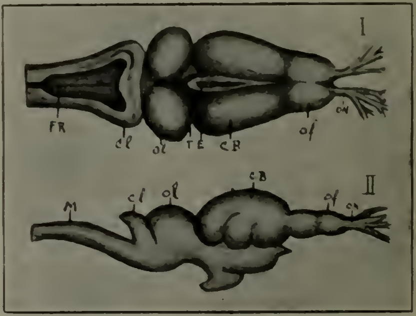


Figure 18
Brain of frog (modified from Hertwig's Manual of Zoology, Kingsley). 1, dorsal view; 2, side view; *m*, medulla; *cl*, cerebellum; *ol*, optic lobes; *cb*, cerebrum; *of*, olfactory lobes; *on*, optic nerve.

from the end towards the spinal cord, they are designated as follows: a single median lobe, the medulla (metencephalon), m; in front of this is another single median lobe, the cerebellum (epencephalon), cl; then the optic lobes (mesencephalon), right and left, ol; then the thalami (thalamencephalon), which are small and hidden from view by the encroachment of the two adjacent segments; then the cerebrum (prosencephalon) cb; and, finally, the olfactory lobes (rhinencephalon). In this fish the largest of the segments are the optic lobes, ol.

THE BRAIN OF REPTILE. The reptile's brain (Fig. 18), shows similar parts with the same serial arrangement. The reptile is a higher, more intelligent animal than the fish and, in consonance with this fact, the cerebrum, not the optic lobes, is the larger more dominant part of the brain.

THE BRAIN OF THE BIRD is more closely related to that of the reptile than the brain of the reptile is to the frog brain. This last is in the same class as the fish (ichthyopsida). The bird and reptilian brain is more closely related to the brain of the egg-laying mammals than to the brain of the higher mammals. The optic lobes, which were most prominent in the fish and less prominent in the reptile, are hardly visible in the bird

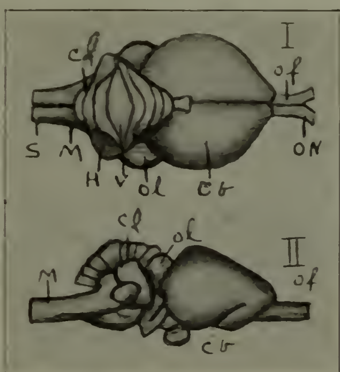


FIGURE 19

Brain of bird (modified from Hertwig's Manual of Zoology, Kingsley). 1, dorsal view; 2, side view; *m*, medulla; *cl*, cerebellum; *ol*, optic lobes; *cb*, cerebrum; *of*, olfactory lobes; *on*, optic nerve.

(Fig. 19), being almost covered by the cerebellum, showing a slight advance in evolution.

IN THE MARSUPIAL OR MAMMAL (Fig. 20), a more intelligent animal still, the cerebrum (cb), has grown so large that it extends backwards and partially covers the optic lobes. In the marsupial, the cerebellum (cl), (like the cerebrum, cb), has evolved to a higher phase. It consists of a median lobe (cb), which is larger than the median cerebellum of the lower

animals described and of two lateral lobes, one on either side, which have been acquired in the course of evolution. The median lobe, the homologue of the single median cerebellum of lower animals, is larger than the lateral ones. The cerebellum of the marsupial has its surface increased by fissures, while that of the fish, reptile and bird is smooth. The fissured cerebellum

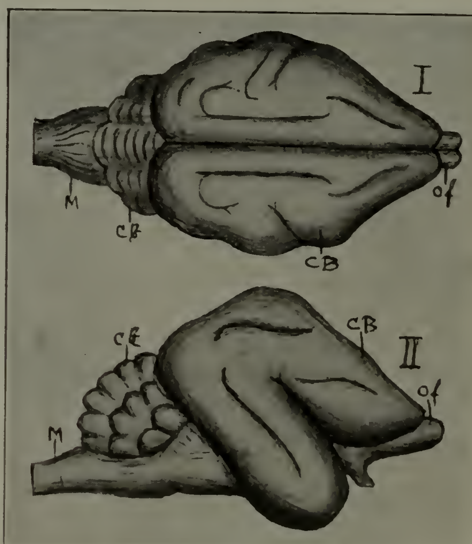


Figure 20
Brain of lemur (modified from Shute). 1, dorsal view; 2, side view; *m*, medulla; *cl*, cerebellum; *cb*, cerebrum; *of*, olfactory lobes.

is a higher evolution than the smooth ones. In the groups of animals referred to so far the cerebrum is smooth and the olfactory lobes are still in front, though much encroached upon in the marsupial by the enlarging cerebrum. In those animals still higher in the scale, like the prosimia (lemurs), the cerebrum has reached yet greater proportions and complexity and has grown still farther backwards towards the medulla, so that it hides from view a considerable portion of the cerebellum (Fig. 20); it has also grown forward, concealing largely the olfactory lobes. The cerebrum, no longer smooth, has a number of simple fissures and convolutions (the higher animals have numerous complex fissures and convolutions). The lateral lobes of the cerebellum have increased relatively more than the central lobe, and the whole organ has advanced in complexity of fissures. In the higher simiae (monkeys and apes) the cerebrum has grown so far backwards as to cover almost completely the cerebellum and medulla and its convolutions have become more numerous and complex. The cerebellum

has also grown greatly and its lateral lobes are now larger and more complex than the central lobe.

Finally in Man (Fig. 21), the whole brain has grown so enormously that it is three times larger than the brain of the highest simiae. The cerebrum, especially, has increased enormously in size. It has grown not only backward (overlapping cerebellum), upward and downward on

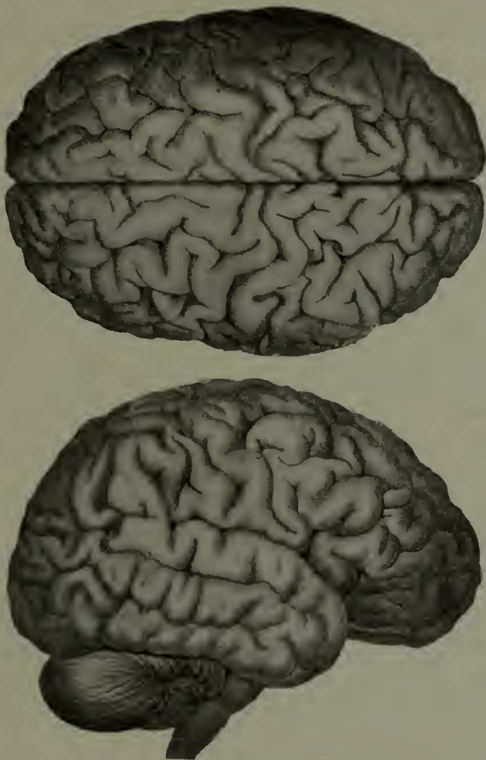


Figure 21

Brain of man (Carus's "Soul of Man"). Dorsal and side views. The cerebrum has grown so far backwards and forwards as completely to hide the other segments of the brain when looked at from the dorsal surface.

the sides, it has grown so far forward as not only to cover the olfactory lobes, but also to project far beyond them. The cerebellum has also increased in size and complexity, especially the lateral lobes. The ideal vertical section (Fig. 22), shows diagrammatically in one figure all these stages in the evolution of the human brain through the geologic ages.

The Ontogeny of the Brain

Very early in the development of the fetus, at about the second week, there occurs complete closure of the anterior end of the neural tube. The cephalic region of this tube is slightly flattened from side to side and presents an appearance of an unequal growth. Two slight constrictions occur, dividing the medullary tube into three enlargements, known as primary brain vesicles.

In the development of the human brain from the fertilized ovum, the stages which are permanent in the zoologic (taxonomic) series, are transient stages.

Early Development of the Human Brain presents three swellings in a serial arrangement. They are known from behind, forwards as the

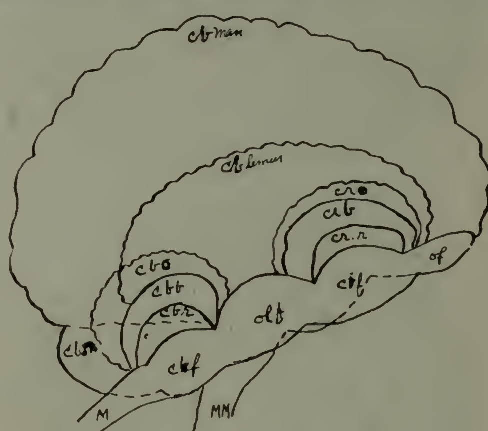


Figure 22

Diagrammatic sketch of the phylogeny and ontogeny of the brain (modified from LeCount). *m*, medulla; *cbf*, cerebellum of fish; *olf*, optic lobe of fish; *crf*, cerebrum of fish; *of*, olfactory lobes of fish; *cbr*, cerebellum of reptile; *cbb*, cerebellum of bird; *cbo*, cerebellum of opossum; *cbl*, cerebellum of lemur; *cbm*, cerebellum of man; *mm*, medulla of man. The convolutions of the cerebrum in phylogenic development begin with the lemur; in the cerebellum from the oppossum.

hind-brain, mid-brain and fore-brain. The fetal brain, in developing from this early condition to a later and higher state, differentiates the hind-brain into the medulla (Fig. 23, m), and the cerebellum, (cl); the mid-brain becomes the optic lobes, (ol); and the fore-brain differentiates into the thalmi (th) and the cerebrum (cr). A little later the cerebrum buds forth the olfactory lobes (of) so that the human brain will consist of six fundamental segments,—one behind the other. This is the fish stage in the growth of the human brain (compare Fig. 23, (1) with Fig. 17).

As development proceeds, the most conspicuous growth of the brain occurs in connection with the cerebrum and cerebellum (Fig. 23, 2). The cerebrum grows relatively and actually larger and larger, but does not yet cover any portion of the optic lobes. This is the reptile stage, (Fig. 18). The cerebrum, continuing to grow (Fig. 23, 3), finally covers the front portion of the optic lobes. This is the marsupial stage (Fig. 20). Growing further, it soon covers a greater or less portion of the cerebellum. These are the prosimian (lemur) and simian stages. Finally it grows so far backward as to completely cover the cerebellum and so far forward as to project much beyond the olfactory lobes. This is the human stage (Fig. 23, No. 4).

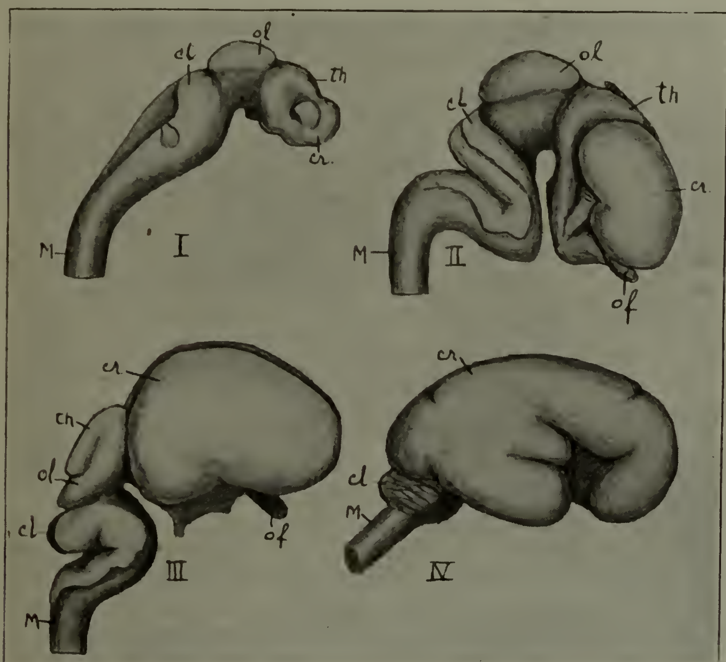


Figure 23

Brain of human embryo in its ontogenic development (His). 1, the fish stage; 2, the reptilian stage; 3, the bird stage; 4, the mammal or human stage; *m*, medulla; *cl*, cerebellum; *ol*, optic lobes; *th*, thalmus; *cr*, cerebrum; *of*, olfactory lobes.

The Cerebrum in fish, reptile, bird and lower marsupial (mammal) is smooth. In the half apes (lemuroidae) it is convoluted; in the simidae, it is still more convoluted, while in man it reaches the climax of complexity in the size, number, and sinuosity of its convolutions. These convolutions

increase the surface of the cortex of the brain, which is the seat of psychic phenomena. Other things being equal, the greater the amount of cortex, the greater is the intelligence. During its embryonic development, the human cerebrum passes through the stage of smoothness to a convoluted condition; then through stages of increasing complexity of convolutions. Simultaneously with this advance of cerebral organization, occurs an unfolding of increasing intelligence.

The Cerebellum presides over the co-ordination of the muscular movements of the body. It, also like the cerebrum, passes through the fish, reptile, bird, marsupial, lemur and simian phases. At first, it consists only of the median lobe; then the lateral lobes appear, at first small in size, but getting larger and larger until they greatly surpass in bulk the more primitive median portion. At first, the cerebellum is smooth, but

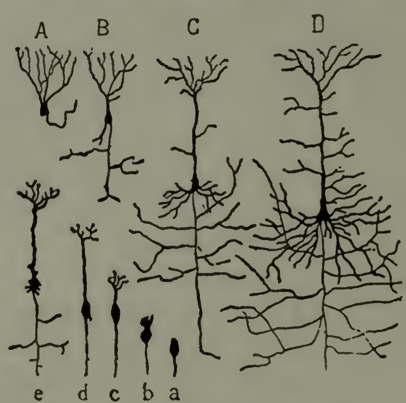


Figure 24

Shows the evolution in phylogeny and ontogeny of the pyramidal cells of the brain (Ramon y Cajal). The upper series of cells represents the psychic cell in various vertebrates; *A*, the frog; *B*, the lizard; *C*, the rat; *D*, man. The lower series show the progressive stages in the evolution of the pyramidal cell in the human brain; *a*, the neuroblast without protoplasmic processes; *b*, the appearance of the nerve process and of the terminal ramifications; *c*, the nerve more fully developed; *d*, appearance of lateral branches of the axis cylinder; *e*, development of protoplasmic outgrowths of the protoplasm of nerve cell and nerve.

as it develops, its fissures become greater and greater, thus increasing its cortex. With the developing cerebellum are associated increasing powers of muscular co-ordination; increasing delicacy and complexity of muscular movements.

Between birth and three months, the brain is one-fifth the weight of the body. In the adult it is one thirty-third. During the first six months, the brain doubles in weight. The effects of stress at this time would, under the law of economy of growth, be felt either in diminution of the

quality or quantity of the brain or in the preservation of these at the expense of more transitory structures like the face, nose, jaws and teeth. In other words, when a given amount of nutriment is sent to the head, there is a struggle between the face, jaws, teeth and brain for the material. If the jaws succeed in obtaining the most there is a return to the anthropoid, the brain becomes proportionately smaller and the jaws larger. On the other hand, if the brain receives the most nutriment, it develops at the expense of the face and jaws. Between two years and six, the same factors, to a lesser degree, are present, while between seven and fourteen, the brain has quadrupled in weight.

THE NEURON CELL UNIT of the cortex of the brain, passes successively through stages corresponding to those which are to be found in the adult, fish, reptile, bird and mammal (Fig. 24). Here the development consists in an increasing complexity of the cell with no formation of unnecessary rudimentary parts. This is also the case when the development of the brain of man is compared with the probable ancestral stages as displayed in the vertebrate series. Arrest of development of the neurons would imply imperfect power of association and consequently imperfect potentialities of education. The brain of man passes, by a long course, through a phase of development in which mental powers, unknown in the ape or merely rudimentary, become highly developed; and as the organ of the mind, the brain remains capable of expansion almost, or quite, to the end of normal life. The nervous and muscular systems retain a power of development by which the execution of new movements can be learned until late in life. Fixity is reached, for the most part, only in those organs, like the skeleton, for which there is no need of adaptation with advancing development. Thus the ontogeny of the brain and its neuron recapitulates its phylogeny.

In his flight from cell to fully developed compound animal, man, at the present period of his evolution has, as a result of a loss in explosive force, developed a nervous system. How well he accomplishes this development depends upon brain health. The nervous system of man develops first, to preside over the development of the other structures. If it be normal, the structures of the body will develop normally; on the other hand, if from any cause it be abnormally developed, unstable or defective, the structures of the body, while developing, become abnormal. When arrests of the brain occur, different classes of degenerates result. The more marked forms are the idiot, insane, criminal, periodical drunkard, deaf-mute and congenital blind. The one-sided genius, the habitual liar, the "smart" business man, the extreme egotist, the tramp, kleptomaniac, harlot and pauper likewise belong here. All display stigmata (deformities, signs) to a marked degree.

All organs of the body have practically an individual nervous system, which exercises a control over their nutrition through its control over the blood supply and the means of excretion. The excessive action of this local nervous system is restrained by the central system for the benefit of the organism as a whole (inhibition). Should the central nervous system become improperly developed, relaxed in check action or weakened, the local nervous system, given free play, first draws nourishment and increased power at the expense of other organs. As a result of this increased power, the local nervous system becomes itself exhausted and a struggle for existence occurs between its parts. In consequence, as in the case of tumors and cancers, cells take on the power of local reproduction which, for a long time, they had lost, for the benefit of the organism as a whole.

Summary

Organs develop from single specialized cells and, with the rise in the animal scale, usually show advance from a lower to a higher state by increasing complexity of organization. The brain controls the development of other organs.

In phylogeny, the changes in the brain are characterized by the increase in size and in complexity of two parts, the cerebellum and the cerebrum, which, in the fish, are smaller than the optic lobes, but in man, overshadow and cover all the other parts of the brain. The increase in size and complexity of the cerebrum is closely associated with increase in intelligence. In the fish, both cerebellum and cerebrum are smooth; in man they are fissured and complexly convoluted.

In ontogeny, the human brain begins by an infolding of the epiblast, which forms, at the anterior end, three swellings, the hind-brain, the mid-brain and the fore-brain. These form, later, the medulla, the cerebellum, the optic lobes, the thalami and the cerebrum from which spring the olfactory lobes. The cerebrum, at first small and smooth, grows so as to cover the cerebellum and extends far beyond the olfactory lobes, and its surface is divided and corrugated into numerous folds and convolutions. The surface is called the cortex; with the increase in amount of cortex, there is a corresponding increase in the amount of intelligence.

The cerebellum co-ordinates muscular movements, and, in proportion to the complexity of its development, the power of performing delicate and finely co-ordinated movements increases.

The individual neurons of the brain undergo a development corresponding to the forms observed in the lower animals.

A struggle for existence between the brain and the jaws and teeth may

result in imperfect development of the brain or in a similar imperfection on the side of the jaws and teeth.

The development and functionation of the various organs is under the control of local nervous systems and all of these are in turn controlled by the brain, which co-ordinates and restrains them for the good of the whole.

Imperfect development of the brain and disturbance in its controlling force, therefore, account for many deformities and abnormal traits of body and mind.

Chapter IV

DEVELOPMENT OF ORGANS

The Heart and Great Arteries

Phylogeny

STUDY of blood vessel phylogeny must begin with the annelids (Class Vermes or Worms). Above and below their digestive tract is a longitudinal blood vessel connected in each section by loops passing around the intestine. In them, the place of the heart is taken, functionally, by contractile blood vessels. This is also the case in the lancelet (amphioxus), the lowest vertebrate. Below its pharynx, in the endostylar coelom, is a more or less contractile blood vessel (the branchial artery), which corresponds in its position and relations to the heart and aorta of the higher forms. The higher vertebrate types develop a heart in the ventral trunk (dorsal of the annelids).

In Fish, the heart close behind the gills, sends them blood from the body, which, like that of the whole ventral, is venous. The dorsal trunk collects from the gills oxygenated blood, which is sent by the carotids to the head, and by the dorsal aorta and vascular loops to the body, where it becomes venous, flowing again into the ventral trunk. The heart, a strong muscular organ in a pericardium, consists of two parts, auricle and ventricle, separated by valves. The trunk (ventral aorta) arising from the auricle is arterial and corresponds to the ascending aorta and pulmonary artery of man. The arterial branches of the gill region, which arise from it, pass directly into the dorsal vessel only in young fishes; later they furnish the branchial circulation of gill arteries, gill capillaries, and gill veins. The dorsal trunk is the dorsal aorta (aorta descendens); the ventral trunk (present in the embryo only), is the sub-intestinal vein, from which the portal vein arises. To this are added a system of paired veins, consisting of Cuvierian ducts, jugular and cardinal veins, the latter gradually encroach on the territory of the sub-intestinal vein.

Fish type circulation undergoes a great modification with the loss of gills and the appearance of pulmonary respiration. Gills and gill capillaries disappear. Branchial circulation is reduced to arterial arches leading direct from the ventral to the dorsal aorta. The swim bladder received its blood from the body (systemic) circulation, but with the functioning of the lungs, pulmonary arteries and veins come into existence, while the

arterial arches in part disappear and in part are divided between the pulmonary and systemic circulations (Fig. 25). Of the six arches which usually appear in the embryo, the first and second and, in animals with lungs, the fifth usually disappear. The last arch (4), which even in the Dipnoi supplies the swim bladder, becomes a pulmonary artery; the other arches (1 and 2) furnish the systemic portions, the dorsal aorta (2) and the carotids supplying the head (1).

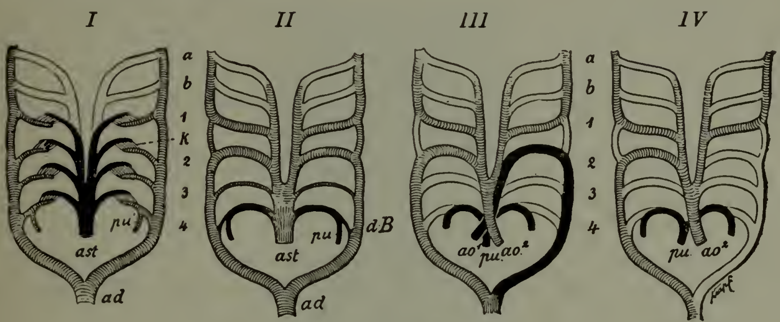


FIGURE 25

Diagram of modification of arterial arches in the various vertebrate classes (Kingsley, Hertwig's Manual of Zoology). White vessels which degenerate; cross-lined, vessels containing arterial blood; black vessels containing venous blood. 1, Dipnoi (sub-class of fish); II, Urodeles (an order of amphibians) with pulmonary respiration; III, Reptiles; IV, Birds, (in mammals the left instead of the right aortic arch persists). ao^1, venous aorta of reptiles; ao^2, arterial aorta; *ast*, arterial trunk; *a*, *b*, arches which usually disappear; *ad*, dorsal aorta; *d*, *B*, ductus Botalli; *k*, gill capillaries; *pu*, pulmonary artery; 1-4, persistent arterial arches.

Since the special pulmonary veins, distinct from the systemic circulation, carry the blood from the lungs to the heart, the heart becomes divided by a septum which separates it into right and left halves. The right half retains the venous character of the fish heart; since the right auricle receives the systemic veins, the right ventricle gives off the pulmonary artery. The left half is purely arterial, receiving arterial blood by the left auricle from the lungs and sending it out through the aorta ascendens to the body. A complete separation of pulmonary and systemic circulation, and a corresponding division of the heart, occurs only in birds and mammals. Amphibia and reptilia show how the modification has been accomplished. In these, separation begins in the venous system and extends to the auricle; in reptiles, the septum arises in the ventricle. In the arterial system, remnants may persist, such as a connection (ductus Botalli) of the pulmonalis with the aorta (II, d b), or an aortic arch may rise with the pulmonalis from the right side of the heart (III, ao).

IN THE GILLED BATRACHIA, the type intermediate between tadpole

and adult, gilled batrachian persists during life. Blood propelling force in reptiles consists of a heart with two auricles and one ventricle. Oxygenated blood from the lungs is forced into the left auricle. The impure blood passes into the right auricle. As the animal has but a single ventricle, the two blood streams mix to some extent, as they pass into the general circulation. In some salamanders, the lungs often disappear and breathing is carried on by the skin.

In Reptiles, the circulation greatly improves over that of the amphibia. The partition of the ventricle is not complete, however, and the pure blood becomes mixed with the impure in its return to the heart. In some reptiles, as the alligators and crocodiles, the partition is complete and the circulation resembles that of the mammal.

In Birds, blood circulation assumes a higher type than in reptiles. Complete separation of the systemic and pulmonary systems takes place. Of the three great arterial trunks connected with the circulation in the crocodile, the pulmonary artery and the right aortic arch arising from the left ventricle are retained; the left venous arch is lost. The septum (in heart evolution) between the ventricles is complete in the bird. The bird ranks higher than the egg-laying mammals. Certain mammals, like the dugong (sea-cow), have a heart which, while united, presents a double appearance. The ventricles are separated. The heart type of the viviparous (live-born) mammal is essentially that of the bird.

The bird being warm blooded, the heart has arrived at its highest development in its evolutionary stage from the pulsating branchial artery of the lancelet through the two-chambered organ of fishes, and the three-chambered organ of reptiles to the four-chambered organ of the higher viviparous mammals.

Ontogeny of the Great Vessels

Ontogeny of the blood vessels closely follows phylogeny. Corresponding to the four visceral arches are four vascular arches. One of these disappears, and the remaining three undergo certain changes, by which they are converted into the vessels going to the head and the superior extremities. The anterior arches on the two sides are converted into the carotids and subclavians; the second, on the left side, is converted into the permanent aorta and the right is obliterated; the third, on either side, is converted into the right and left pulmonary arteries.

The branchial arch changes are illustrated in Fig. 26. In this the three branchial arches that remain and participate in the development of the upper portion of the vascular system are 1, 2, 3, on either side. The two anterior (3, 3) become the carotids (c, c) and the subclavians (s, s).

The second (2, 2) is obliterated on the right side and becomes the arch of the aorta on the left side. The third (1, 1), counting from above downward, is converted into the pulmonary arteries of the two sides. Upon the left side, there is a large anastomosing vessel (ca), between the pulmonary artery of that side and the arch of the aorta, which is the *ductus arteriosus*. The anastomosing vessel (cd), between the right pulmonary artery and the aorta, is obliterated.

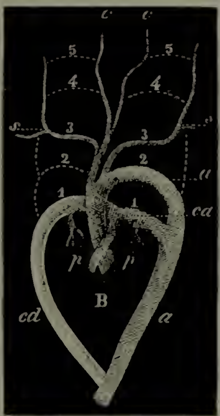


FIGURE 26

Transformation of the system of aortic arches into permanent trunks in the mammalia (Von Baer). *B*, aortic bulb; 1, 2, 3, 4, 5, on either side, the five pairs of aortic arches; 5, 5, the earliest in their appearance; 1, 1, the most recent; *c*, *c*, the two carotids, still united, which are separated at a later period; *s*, *s*, the two subslavians, the right arising from the arteria in nominata; *a*, *a*, the aorta; *p*, *p*, the pulmonary arteries; *ca*, the ductus arteriosus; *cd*, the left arterial canal, which is finally obliterated.

VEIN DEVELOPMENT is very simple. Two venous trunks make their appearance by the sides of the spinal column, which are called the cardinal veins, and run parallel with the superior vertebral arteries, or the two aortae, empting finally into the auricular portion of the heart, by two canals, which are called the canals of Cuvier. These veins change their relations and connections as the first circulation is replaced by the second. The omphalo-mesenteric vein opens into the heart between the two canals of Cuvier. As development advances, the liver is formed in the course of this vessel, a short distance below the heart, and the vein ramifies in its substance; so that the blood of the omphalo-mesenteric vein passes through the liver before it goes to the heart. The omphalo-mesenteric vein is obliterated as the umbilical vein makes its appearance. The blood from the umbilical vein is at first emptied directly into the heart; but this vessel soon establishes the same relations with the liver as the omphalo-

mesenteric vein and its blood passes through the liver before it reaches the central organ of the circulation. As the omphalo-mesenteric vein atrophies, the mesenteric vein, bringing the blood from the intestinal canal, is developed, and this penetrates the liver, becoming finally the portal vein.

As the lower extremities are developed, the inferior vena cava makes its appearance, between the two inferior cardinal veins. This vessel receives an anastomosing branch from the umbilical vein before it penetrates the liver and this branch is the ductus venosus. As the inferior vena cava increases in size, it communicates below with the two inferior cardinal veins; and that portion of the two inferior cardinal veins which remains constitutes the two iliac veins. The inferior cardinal veins, between that portion which forms the iliac veins and the heart, finally become the right and left azygos veins.

The right canal of Cuvier, as the upper extremities are developed, enlarges and becomes the vena cava descendens, receiving, finally, all the blood from the head and the superior extremities. The left canal of Cuvier undergoes atrophy and disappears. The upper portion of the superior cardinal veins is developed into the jugulars and subclavians on the two sides. As the lower portion of the left cardinal vein and the left canal of Cuvier atrophy, a venous trunk appears, connecting the left subclavian with the right canal of Cuvier. This increases in size and becomes the left vena innominata, which connects the left subclavian and internal jugular with the vena cava descendens.

Ontogeny of the Heart

The first traces in the development of the human heart occurs about the tenth or twelfth day, in the form of a mass of cells proceeding from the middle layer of the blastodermic vesicle and the anterior wall of the intestinal cavity. It soon forms a bent tube lying in front of the embryo and only connected to it by its vessels. The heart is situated at first at the anterior end of the embryo, lying opposite the last two cerebral vesicles. As the head is developed, the heart falls, as it were, backwards to the lower part of the neck and then to the thorax. It fills the whole thoracic cavity about the second month. As the lungs and thoracic parietes form, the heart assumes its permanent position.

This hollow cellular structure elongates into the tube, which very soon assumes a shape somewhat like an S (Fig. 27) and there are indications of its being subdivided into (a) an upper aortic part with the bulbus arteriosus; (b) a middle or ventricular part; and (v) a lower venous or articular part. The heart then curves on itself in the form of a horseshoe (2) so that the venous end (A) comes to lie above and slightly behind the

arterial end. On the right and left sides respectively, of the venous part is a blind hollow outgrowth which forms the large auricle on each side (3, o, o). The flexure of the body of the heart corresponding to the great curvature (2, V) is divided into two large compartments (3), the division being indicated by a slight depression on the surface. The large truncus venosus (4, v), which joins with the middle of the posterior wall of the auricular part, is composed of the superior and inferior venae cavae. This common trunk is absorbed at a later period into the enlarging auricle and thus arise the separate terminations of the superior and inferior venae cavae. In man, the heart soon comes to lie in a special cavity, which in part is bounded by a portion of the diaphragm (His.).

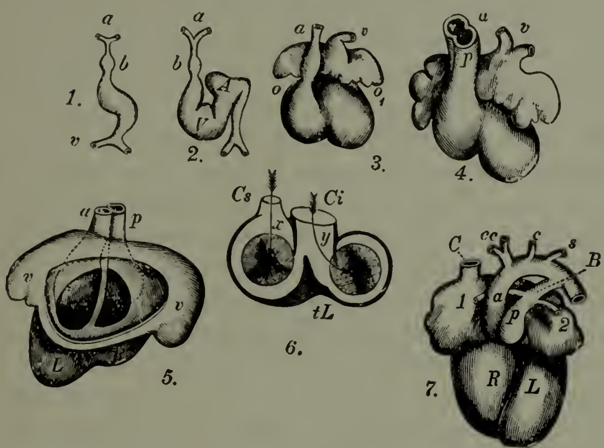


FIGURE 27

Development of the heart (Landois and Stirling). 1, early appearance of the heart, *a*, aortic part with the bulbus, *b*; *v*, venous end. 2, horseshoe shaped curving of the heart —*a*, aortic end with the bulbus, *b*; *V*, ventricle; *A*, auricular part. 3, formation of the auricular appendages, *o*, o^1, and the external furrow in the ventricle. 4, commencing division of the aorta, *p*, into two tubes, *a*. 5, view from behind of the opened auricle, *v*, *v*, into the *L*, and *R*, ventricles, and between the two latter the projecting ventricular septum, while the aorta (*a*) and pulmonary artery (*p*) open into their respective ventricles. 6, relation of the orifices of the superior (*Cs*) and inferior vena cava (*Ci*) to the auricle (schematic view from above)—*x*, direction of the blood of the superior vena cava into the right auricle; *y*, that of the inferior cava to the inferior cava to the left auricle; *tL*, tubercle of Lower. 7, heart of the ripe fetus—*R*, right, *L*, left ventricle; *a*, aorta with the innominate, *cc*, carotid, *c*, and left subclavian artery, *s*; B, ductus arteriosus; *p*, pulmonary artery with the small branches 1 and 2 to the lungs.

THE CHAMBERS. At the fourth to fifth week, the heart begins to be divided into a right and a left half. Corresponding to the position of the vertical ventricular furrow, a septum grows upward vertically in the interior of the heart and divides the ventricular part into a right and left

ventricle (5, R. L.). There is a constriction in the heart, between the auricular and ventricular portions, forming the canalis auricularis. It contains a communication between the auricle and both ventricles, lying between an anterior and posterior projecting lip of endothelium, from which the auriculo-ventricular valves are formed (F. Schmidt). The ventricular septum grows upward toward the canalis auricularis and is complete at the eighth week. Thus, the large, undivided auricle communicates by a right and left auriculo-ventricular opening with the corresponding ventricle (5). At the same time two septa (4, p a) appear in the interior of the truncus arteriosus (4, p), which ultimately meet, and thus divide this tube into two tubes (5, a p), the latter forming the aorta and pulmonary artery, and are disposed toward each other like the tubes in a double-barreled gun. The septum grows downward until it meets the ventricular septum (5), so that the right ventricle comes to be connected with the pulmonary artery and the left with the aorta. The division of the truncus arteriosus, however, takes place only in the first part of its course. The division does not take place above, so that the pulmonary artery and aorta unite in one common trunk above. This communication between the pulmonary artery and the aorta is the ductus arteriosus Botalli (7, B).

Vascular Relations. In the auricle, a septum grows from the front and behind, ending internally with a concave margin. The vena cava superior (6, Cs) terminates to the right of this fold, so that its blood will tend to go toward the right ventricle, in the direction of the arrow in 6, x. The cava inferior, on the other hand (6, Ci), opens directly opposite the fold. On the left of its orifice the valve of the foramen ovale is formed by a fold growing toward the auricular fold, so that the blood current from the inferior vena cava goes only to the left, in the direction of the arrow, y; on the right of the orifice of the cava and opposite the fold, is the Eustachian valve, which, in conjunction with the tubercle of Lower (tL), directs the stream from the inferior vena cava to the left into the left auricle through the pervious foramen ovale. After birth, the valve of the foramen ovale closes that aperture, while the ductus arteriosus also becomes impervious, so that the blood of the pulmonary artery is forced to go through the pulmonary branches proceeding to the expanding lungs. Sometimes the foramen ovale remains pervious.

Though the heart is composed at first of a mass of fetal cells, its rhythmic contractions can be observed even in this condition before the development of any muscular fibres, and even, according to some authors, before it is in connection with any nerve fibres.

At birth, the heart is small relatively to the arterial system, but this disproportion gradually disappears until puberty when, according to Beneke, the relation is changed. The larger the heart, relatively, to the

vessels, the higher the blood pressure and the earlier, stronger and more complete is the development of puberty. The weight of the heart from birth increases twelve and a half times. Strain, interfering with heart growth would either affect it or, under the law of economy of growth, the more transitory structures are lost for its benefit.

Arrests in Phylogeny and Ontogeny of heart development appear in cardiac malformations such as the partitions of the heart remain undeveloped at the ichthyopsida (certain fishes) and reptilian stage. These frequently occur in so-called "blue babies."

In mammals, the aorta normally passes to the left of the vertebral column; in reptiles it divides and passes to both sides. Not infrequently in ontogeny there is an arrest in phylogeny in which the arch divides and passes to both sides at the reptilian stage. Hommel, in 1737, was the first to record findings of this character. Meckel noticed an abnormality in which the two divisions united after encircling the trachea.

In transplantation of the viscera, as occasionally found in the dissecting room, appearance of the aorta and the heart are found upon the right side is a reversion to the bird type.

Heart malformations, as based on analysis of four hundred and twelve specimens, show arrests and excessive development existing at birth. Many of these, studied from a phylogenetic standpoint, show persistence in the adult stages of fish, reptile, bird, oviparous and lower mammal tendencies.

Summary

Phylogeny

In the lowest types of animal life, the annelids and amphioxi, the heart is simply a more or less contractile blood vessel, corresponding in position and relations to the heart and aorta of the higher animals.

In fish, the heart is a strong muscular organ in a pericardium, with auricle and ventricle, separated by valves, receiving oxygenated blood from the gills by the dorsal trunk, and venous blood from the body of the ventral. This type of circulation is radically modified with the disappearance of gills and the establishment of pulmonary respiration. Special pulmonary arteries and veins now appear, and with this separation of the pulmonary from the systemic circulation, the heart is divided by a septum into right and left halves. The complete separation is only achieved in birds and mammals, but in the amphibia and reptilia, the intervening modification is seen.

In reptiles, the circulatory system shows a great advance over that

of the amphibia. The septum arises in the ventricle, but the partition is incomplete, so that the arterial and venous blood become mixed in their return to the heart, and in the arterial system remnants of the old order of things frequently persist, such as connections between the pulmonary artery and the aorta, etc. In some of the higher reptiles, the partition is complete, and the circulation similar to that of mammals.

In birds, the circulation shows a much higher development than in reptiles, and, in fact, higher than in the egg-laying mammals, being essentially the same as in the viviparous mammal. The heart is a four-chambered organ which is fundamentally the highest stage of its evolution; separation of the pulmonary and systemic circulations is complete; and the arterial and venous economy is essentially the same as in the higher mammals.

Ontogeny

The ontogeny of the vessels is a replica of their phylogeny. The heart first assumes a hollow, elongated, tubular shape, which subsequently bends on itself, the flexure being divided into two large compartments. At the fourth to the fifth week in the human fetus the heart begins to be divided into right and left halves, a septum growing up through the ventricle, followed later by the downward growth of a septum dividing the auricle, which meets the ventricular septum. The arteries and veins follow a corresponding structural and relational development.

Rythmic contractions are observable in the heart even in its elementary cellular condition, and, according to some authorities, before its connection with nerve fibres.

At birth, the heart is relatively small compared with the arterial system, the disproportion gradually disappearing until at puberty, when the relativity is reversed. This constitutes one of the points of strain in puberty. The greater the relative size of the heart in the child, the better the development at puberty.

Arrests in heart development are sometimes seen of both a phylogenetic and an ontogenetic character, which manifest themselves as malformations (perforated septa, divided aortae, etc.).

Chapter V

DEVELOPMENT OF ORGANS

The Liver

Phylogeny

THE PHYLOGENY OF THE LIVER begins in a co-operative way in different developing structures known as hepato-pancreas or liver pancreas. Later on each part becomes a complete separate organ with its special function.

THE AMPHIOXUS has a blind pouch, lined with columnar epithelium secreting a digestive fluid, and known as the liver or hepatic caecum.

THE DOG FISH has a large liver composed of two elongated lobes, with a gall bladder at the anterior end of the left lobe. Ducts connect the gall bladder with the right and left lobes of the liver; a duct opens into the beginning of the colon.

IN THE TROUT, the liver is imperfectly developed into two lobes. The gall bladder is comparatively large.

IN THE FROG, the liver is early recognizable as a diverticulum pushed out from the front end of the digestive tract in a ventroposterior direction. The walls of this diverticulum thicken and become folded, and the mesoblast penetrates between these folds. The liver is two-lobed. The diverticulum (evidently lined with entoblast) persist as the bile duct. From it, an outgrowth arises to form the gall bladder which lies between the two lobes.

LIZARDS have a two-lobed organ. The ontogenetic advance seems to be marked by the change of position of the gall bladder, which lies at the lower margin of the right lobe.

IN THE CHICK, the origin of the liver as a median outgrowth from the floor of the digestive tract, occurs as in the frog.

"The liver arises (Marshall) about the middle of the third day, as a tubular diverticulum from the posterior end of the fore-gut, in the angle between the two vitellin veins, and immediately behind their point of union. A second diverticulum arises from the same spot, almost directly afterwards; it is similar to the first, but of rather smaller size. Both these diverticula have hypoblastic walls, with thin, mesoblastic investments.

"Towards the latter part of the third day, as the folding off of the embryo from the yolk-sac proceeds, the liver diverticula are found to arise

definitely from the part of the mesenteron, which will later become the duodenum. At the same time, they come into very close relation with a very large median vein, the meatus venosus, which is formed by the union of the right and left vitellin veins behind the heart.

"The two liver diverticula lie on each side of the meatus venosus, and in very close contact with this. The hypoblastic cells, forming the walls of the diverticula now begin to proliferate freely, growing out as solid strands of cells, which form an irregular reticulum, closely surrounding the meatus venosus; the meshes of the reticulum being occupied by the capillary blood vessels, which develop in the mesoblast, and early acquire connection with the meatus venosus itself. These processes proceed rapidly during the fourth and fifth days, and by the end of the fifth day, the liver is a solid organ of considerable size, consisting of a network of solid rods of hypoblast cells, which branch and anastomose freely in all directions; the meshes of the network being occupied by blood vessels which penetrate all parts of the liver and are in free communication with the meatus venosus round which the liver is formed.

"The liver continues to grow rapidly. By the tenth day, it is the largest organ in the abdomen. The trabecular network of hypoblast cells becomes the liver parenchyma; the tubular diverticula, from the duodenum, branch out freely in the substance of the liver and become the two bile ducts of the adult bird; while the gall bladder arises on the fifth day as a sacular outgrowth from the right, or larger, of the two primary diverticula."

The early formation of the liver in the chick, and its large size during the greater part of the developmental history, indicate its functional importance during embryonic life. Its relation to the blood system, and especially the fact that it intercepts the blood returning from the yolk-sac to the heart, indicates that its chief purpose is elaboration of food material from the yolk-sac by which nutrition of the embryo is affected.

Mammalian Development. Marked developmental changes are seen in the liver of the rabbit, which is five-lobed. A fold of peritoneum attaches it to the diaphragm. Hepatic ducts from the gall bladder unite to form a common bile duct, which opens into the duodenum.

In other mammals, the liver consists of two parts of main divisions, right and left, incompletely separated from one another by a fissure termed umbilical, owing to its marking the position of the fetal umbilical vein. Usually, each of these main divisions is divided by a fissure into two parts, so that the right lateral and right central and left lateral and left central are distinguishable. When a gall bladder is present, as it is in the majority of mammals, it is attached to or imbedded in the right central lobe. A fissure, the portal, through which the portal vein and hepatic artery enter

the substance of the liver, and hepatic vein passes out, crosses the right central lobe near the anterior border. The post-cavel lies in contact with, or imbedded in the right lateral lobe near its anterior border, and given off from this lobe between the post-cavel and the portal fissure, is a small lobe of varying extent—the spigelian. The term *caudate lobe* is applied to the process of the right lateral lobes of considerable extent in most mammals, having the post-cavel vein in intimate relation to it and often closely applied to the kidney. A gall bladder is usually present. It is absent in the Cetacea, Hyracoides, in some rodents, the Perisodactyl and Ungulata.

Ontogeny

The development of the human liver is similar to that of the chick and mammals. The liver has undergone similar changes to the kidney, being an older organ in phylogeny of vertebrates than the heart. Embryologically and morphologically, it is composed of two distinct parts, one related to excretion and the other to secretion, assimilation, glycogenesis, sanguifaction and metabolism. These parts are first a branching system of epithelial gall ducts, and secondly a network of hepatic cylinders.

The Gall Ducts are surrounded by connective tissue, and, as is well known, are accompanied by the branches of the portal vein and hepatic artery.

The Hepatic Cylinders are separated from one another only by endothelial blood vessels. The essential primitive features of the hepatic cylinders are an epithelial tube with a small central lumen and covered by an endothelium, which is easily recognized by its flattened, darkly-stained nuclei; the endothelium is the wall of a blood vessel or channel. The hepatic cylinders, by branching and uniting, form a network, all the meshes of which are entirely occupied by blood vessels. In sharks, each cylinder comprises in its cross section, usually, eight or ten cells and is almost completely bathed in blood. In amphibia, the cylinders are smaller; they comprise only four to five cells in cross section, their lumen is very small, and the blood channels between them are relatively diminished. In mammals, each hepatic cylinder comprises merely two epithelial cells; the lumen is reduced to a minute canal (the gall capillary); the cylinders anastomose with one another very frequently and at very short intervals; and, finally, the blood vessels between the cylinders become smaller, for the most part, than the cylinders. In mammals, the hepatic cylinders are gathered into radiating groups; the groups are the lobules of descriptive anatomy.

Fetal Development. The liver commences, as stated, as a diverti-

culum of the endodermal canal, extending into the septum transversum. This single median diverticulum may be designated as the amphioxus stage, since a similar diverticulum in the cyclostome is regarded, probably correctly, as the homologue of the primitive hepatic anlage of true vertebrates. From this point, the liver passes through the different stages of typical development from fish to reptile and from bird to mammal.

During the second month of fetal life, the liver is relatively enormous; during the third month it fills the greater part of the abdominal cavity. After the fifth month, the intestines and other viscera overtake the liver; still the liver of the child at birth is twice the size of that of the adult. Immediately after birth, the liver diminishes. The right lobe, always larger than the left, increases in predominance after birth. Very early in fetal life, the liver becomes the principal seat of blood formation. As Claude Bernard has shown, the glycogenic function of the liver begins in the embryo. After birth, the nutritive function of the liver becomes subservient to the excretory function. This is shown by the atrophy of the hepatic cylinders described by Toldt and Zuckerkandl. Arrest of development at certain times would produce the diabetic states, so fatal to children. Such arrest, resembling phylogenetic development, may result from premature senility, from strain arising before but evinced during the first dentition, or from effects of constitutional disorders at early periods of stress. While the liver does not entirely lose its originally great poiogenetic powers, still these proportionately decrease with the evolution of the rest of the poiogenetic agencies in the embryo.

Summary

Phylogeny

The liver has its beginnings, in combination with the pancreas, as a double or co-operative structure, which later separates into two distinct organs.

Its early formation in the various species is indicative of its functional importance to fetal life as an elaborator of nutrition.

Structurally, its evolution is marked by division into lobes and later into two parts, right and left, incompletely separated from each other by a fissure. Functionally, by its less and less activity as a nutrient organ and its more and more importance as an excretory one.

Ontogeny

Here, as elsewhere, ontogeny is a replica of phylogeny. It is developed by a co-operation between the hypoblastic cells, forming the epithelium

of the digestive tract, and the mesoblastic cells which form the connective tissue framework. The mucous membrane forms a pouch which divides and ramifies until it forms the complicated system of biliary canals. The connective tissue carrying the blood vessels and the parenchymatous liver cells, is grouped in lobules around the terminal biliary ducts.

The liver is developed in two portions, right and left. Its relative importance is greatest in fetal life. Its originally great blood-forming functions decrease in importance as other blood making organs are developed. Its detoxicating powers increase.

Chapter VI

DEVELOPMENT OF ORGANS

The Kidney

Phylogeny

THE earliest phase of kidney is the contractile vacuole of the protozoa. Increased specialization of cells is brought about in two ways; a greater number of cells involved in the changes and increased functional activity meet the growing demands. The progress is regular. The water vessels of the planaris, the nephridial tubes and anal opening of the Nemertinae, the excretory vein and pore of the ascaria, all evince advance.

In the Lowest Vertebrate, (the amphioxus), the excretory function is carried on by ninety pairs of peculiarly modified nephridia, situated above the pharynx and in relation with the main coelomic cavity.

In Craniata, the dog fish furnish type of early kidney development. In the dog fish "each kidney consists of two parts, anterior and posterior." The former is a long, narrow ribbon of soft, reddish substance which runs along throughout a great part of the body cavity at the side of the vertebral column. The ducts of the anterior portion are narrow tubes which dilate and form a pair of elongated chambers, the urinary sinuses, which unite into a median sinus, opening into the cloaca. The ureters are developed in the dog fish, being the ducts of the posterior portion of the kidney. There may be four or six of these and they open into the urinary sinus.

The Kidneys of the Trout differ somewhat from those of the dog fish. The progressive phase here is development of a urinary bladder. The ureters (mesonephric ducts) unite in a single tube which dilates to form the bladder. The kidneys are relatively large and are partly fused together in the median line. This condition re-appears in the "horseshoe" kidney of man. In adult life, the anterior portion is lymphatic tissue and the renal function ceases.

In Amphibia, the adrenal body is developed. In the tadpole, a large pronephros is, for a time, the functionating kidney. From the mesonephros and mesonephric ducts of the embryo are developed the kidneys and ureters. There are a number of irregularly scattered nephrostomes; these, however, do not connect with the urinary tubules, but serve to carry lymph from the coelom to the venous system.

In Reptiles (the lizard), the kidneys show little or no distinctive change. Previous changes are more clearly and definitely outlined.

In the Pigeon, the kidneys are developed from the metanephros, the mesonephros (or Wolffian body), undergoing complete atrophy. The more characteristic shape of the organ is about the only change noted.

In Mammals, there is a firm, compact, oval organ. Vessels leave and enter at the hilus or notch. The central secreting portion, the medulla, is usually distinctly separated from the cortex, or outer portion which contains the straight tubules, carrying the secretion to the ureters.

In some mammals (some primates, the carnivora and rodentia), this marked division of the kidney substance is absent, but in others (the bear, seal and cetacea) the markings are so accentuated that they extend to the external surface, dividing the organ into lobules.

In the kidney of the rabbit, several phylogenetic changes are manifest. The shape is oval. The hilus is developed. In the ontogenetic development the relative position of the two organs shows an advance toward the kidney of man,—the right being slightly in advance of the left. The substance of the kidney shows the division into cortical and medullary areas. The pelvis of the kidney is noted for the first time, forming the dilated beginning of the ureters.

In the development of the vertebrates, occurs an evolution of organs for disposing of urinary waste which, after serving the purpose of the lower members of the class, become unsuited to the conditions necessitated by advance in evolution and give place to a second set of organs better adapted to the complex needs of the more advanced species. The organs first developed appear temporarily in the higher animals, but, having given place to their more perfect successors, they atrophy or are devoted to other uses.

Ontogeny

Gain and Loss Process. In intrauterine development (ontogeny) the disappearing and developing tendency is peculiarly well illustrated in the embryogeny of the genito-urinary system, which in all vertebrates contains rudimentary organs.

The Pronephros. The first stage in the formation of the kidney system is the pronephros (Fig. 28 a), which consists of intricate canals, (a, a, a,) opening into the body cavity at the point where the glomeruli are formed on the sub-intestinal vein. As a temporary structure, the pronephros attains considerable development in many fishes and amphibians; in the higher animals, even as an embryonal, it remains very rudimentary and transient. These canals originally had apertures to the exterior. Later on, they became connected with one excretory canal (c) opening into the cloaca, [ce, sauropsidia (reptiles and birds)]. The primitive genital gland was situated close to the pronephros.

The Mesonephros. In the process of embryogeny, the mesonephros, at first distinct from its origin, replaces the pronephros (Fig. 28, b). The mesonephros, a secretory urinary gland (g), with its secretory canal (c), (segmental duct), in appearance closely resembles the pronephros. The urinary system thus formed continues to be closely connected with the genital gland, the discharging canal of which passes through the mesone-

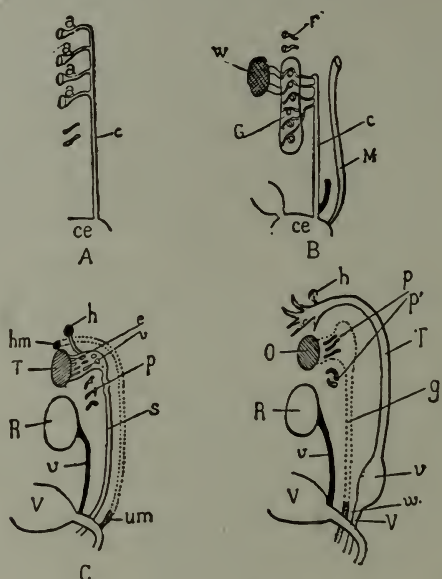


Figure 28

Development of the uro-genital system in higher vertebrates (DeMoor). *A*, pronephric stage; *a*, tubules; *c*, excreting duct; *ce*, cloaca; *B*, mesonephric stage; *G*, mesonephros; *r*, remains of pronephros; *c*, excreting canal; *w*, neutral genital gland; *M*, Muller's duct; *ce*, cloaca; *C*, metanephric or adult stage in the male; *R*, permanent kidney; *U*, ureter; *V*, bladder; *T*, testis, *e* and *r*, epididymis and vas deferens; *s*, vas deferens; *hm*, hydatid of Morgagni; *h*, hydatid; *p*, paradidymis; *um*, uterus masculinus; *D*, metanephric or adult stage in the female; *R*, permanent kidney; *U*, ureter; *V*, bladder; *O*, ovary; *p* and p^1, parovarium and paraophron; *w*, Weber's organ; *V*, vagina; *u*, uterus; *t*,aperture of Fallopian tube; *h*, hydatid.

phric kidney to find exit through the segmental duct. During the mesonephric stage Muller's duct (m) forms, starting from the cloaca and opening out into the general body cavity. The mesonephros does not become the permanent kidney.

The Metanephros. In the course of embryogeny, the metanephros (the permanent excretory kidney) develops Fig. 28 (cb). This development is attended by important modification; further instances of degeneration occur and fresh organic connections are established. In the male,

Fig. 28 (c), the mesonephros begins to atrophy. The part connected with the testes is transformed into the epididymis and the vas deferens (e and v). The remaining part atrophies. When the permanent organization is attained, the atrophied part persists as a paradidymis (p), and a hydatid (h)—organs without functions in the adult state. The discharging canal, which during the mesonephric stage is common to both urinary and genital glands remains simply in connection with the testes and then becomes the vas deferens (s), the terminal extremity of which (the cloaca, having disappeared) becomes gradually individualized. The permanent kidney (r) is connected with a fresh canal—the ureter (u), formed by degrees at the expense of the primitive discharging canal and subsequently separated from the latter in order to empty itself into the bladder (v). Muller's duct, which first increases in size, proceeds at a certain stage to atrophy until all that remains are the distal and proximal extremities in reduced organs (the hydatid of Morgagni (h m) and the male uterus (u m), neither of which is functional. The intervening part of the duct remains to form the canal of Gasser. The adult male genito-urinary apparatus, therefore, comprises: (1) organs which have come into existence at different times, but which have retained their original functions—the testes, the kidneys (metanephros) and the ureter; (2) organs which are functional, but of which the ultimate function differs from the original—the epidiymis and vas deferens; (3) reduced organs, vestiges of what were formerly active organs—the hydatid and the paradidymis; (4) reduced organs, vestiges of Muller's duct which becomes active only in the female—the hydatid of Morgagni and the male uterus.

Kidney Development in the Female (Fig. 28, b), is similar as to physiologic atrophy and hypertrophy. In that part of the mesenephros connected with the genital gland and the corresponding discharging canal, the canal, as a rule, disappears. Exceptionally it forms Gartner's duct (g). The lower part persists in a rudiment (Weber's organ (w)); the upper part becomes reduced to a small tissue which surrounds the paraovarium (p), paraophoron (p)—vestiges of the former mesonephros. Muller's duct becomes considerably enlarged, forming the vagina, the uterus and the Fallopian tubes. At the upper end it is connected with the hydatid, a vestige of the mesonephros. The genito-urinary female apparatus contains some organs, the function of which remains unchanged—the ovaries, the permanent kidney, the Fallopian tubes, the uterus, the vagina, and the ureter; and some rudimentary organs (vestiges of once active organs)—the paraovarium, the paraophoron, hydatid and Weber's organ.

The complicated development of this system becomes clear if careful study be made of the phylogeny of the genito-urinary apparatus. The various phases through which the embryos of the higher vertebrates pass

are stages similar to those which may be observed in the adult lower vertebrates. The principle of recapitulation, that the embryonic structures of higher animals pass through the successive stages attained by the adults of lower animals, receives a full corroboration from the fact cited. The amphioxus, for instance, remains still at the pronephric stage; fish, at the mesonephric stage, or permanent kidney. Some lizards (lacerta) up to the age of two years make use of the mesonephros as the eliminating urinating organ. At the same time, they make use of the metanephros which is also functional. In chamoeles, the mesonephros remains partly active throughout life. Birds and mammals completely lose the mesonephros and, in the adult stage, the metanephros is the only active kidney. Arrests in ontogeny, therefore, may take place at any of the adult stages of the lower vertebrates. In another chapter arrests in development of these structures will be considered.

Congenital Abnormalities of the Kidneys may affect (a) their shape, size, and number; (b) their position; and the kidneys that are abnormal in one of these respects are apt to be so in others.

(a) Abnormalities as to shape, size and number.—One kidney may be congenitally absent or greatly atrophied; may be constricted so as to assume an hour-glass shape; or lobulated, as in the fetal condition; or the two kidneys may be fused so that (1) their inferior portions are united by a band of tissue—glandular or fibrous—that crosses the vertebral column, usually in the lumbar region ("Horseshoe kidney").

This condition is characterized by the presence of, at least, two ureters. There must, of course, be a marked change in the form and position of the kidneys, for even though one kidney occupy its normal position and the other one is joined to it, there must be an absence of kidney on the other side. The commonest form of double kidney is the horseshoe kidney (ren arcuatus). The "arch" is almost always made by the union of the lower ends of the two kidneys in front of the vertebral column. This gives the double organ a crescentic shape with its concavity upward. The reverse position is sometimes seen. The renal pelves are directed forward and both ureters and blood vessels are frequently increased in number. The attachment of the two kidneys may be slight, or it may be so complete that only a fold shows where the two are joined. One kidney may be over-developed and the other one small. This anomaly is found once in 1100 autopsies, and once in about two hundred of the defective classes.

A unilateral long kidney (ren elongatus), is much more rare. Both kidneys are then found on one side of the vertebral column and the lower pole of the upper kidney is united to the upper pole of the lower one by a thinner or thicker mass of parenchymatous tissue. The pelves of the kidney may be turned in opposite directions, giving an S shape to the

whole organ. In this condition, the ureter of the misplaced kidney crossed the abdominal vessels, the vertebral column and the ureter of the other kidney.

The two kidneys may be united in a third form which has been compared to a shield (ren scutaneus). This form is the result of an intimate fusion of both kidneys to a round, more or less flattened organ, which usually lies in the center of the abdomen, rarely upon either side. There are generally two ureters. This type of abnormality may be looked upon as a horseshoe kidney, with union of both lobes and the posterior margins. The pelves form a groove in the center of the anterior surface, from either side of which springs a ureter. The vena cava crosses a portion of the kidney, while the aorta lies wholly behind it.

An abnormality which possesses a far greater importance is the imperfect development of one kidney (hypoplasia renis), or its entire absence. A hypoblastic kidney may be of any size. It may be made up of fibrous tissue, with some rudimentary tubules and glomeruli, or it may contain a certain amount of well-formed parenchyma. There may be cysts in the connective tissue.

The ureter may be completely absent, or it may exist without a lumen, or it may be formed, but abnormally small. It may be obliterated in places and pervious in places. The pelvis of the kidney may be absent or rudimentary. It is worth mention that the lower portion of the ureter may naturally open into the bladder, so that the passage of the ureteral catheter for a certain distance is no proof of the existence of an active kidney.

Defect of one kidney is frequently associated with defects or anomalies of the sexual organs and with other degeneracies. If one kidney be wanting, the suprarenal capsule may be absent, but is usually present. The single kidney, usually normal in position and shape, may be malformed or misplaced.

Congenitally absent kidney has been observed once in 3370 autopsies. Only a single kidney is four times as frequently absent among the defective classes.

Both kidneys have been absent in many still-born children and acephalous monsters. In a very few cases, a supernumerary kidney has been found.

Anomalies affecting the blood supply to the kidney occur in nearly fifty per cent of cases. The renal arteries are usually increased in number or divide at once—before reaching the bilum—into several branches, fetal conditions in the human species that are permanent in many birds and reptiles. Accessory or supernumerary veins are much more rarely found.

Anomalies of position.—Congenital displacement—apart from the

horseshoe kidney—usually affects one kidney, which is apt to be found in the vicinity of the sacral promontory or the sacro-iliac joint, but may be either higher or lower, and maybe its malposition gives rise to serious or even fatal error in diagnosis or treatment.

Summary

Phylogeny

In the lower vertebrates, the urinary excretory gland is developed from a pronephros, which is not the homologue of the kidney of the higher classes. The urinary bladder is not developed in the lower genera. In the tadpole, the pronephros is, for a time, the functionating kidney. The kidney of the adult frog is developed from the mesonephros. In the amphibia, the adrenal body is first developed. In the pigeon, the kidney is developed from another structure, the metanephros. In mammals, the organs become more compact and approach the form and position which it has in man.

Ontogeny

In man, the pronephros and mesonephros appear as transient structures, to disappear, giving place to the metanephros, which forms the permanent kidney.

Chapter VII

DEVELOPMENT OF ORGANS

The Head and Face

Phylogeny

THE phylogeny of the head and face is, perhaps, the most interesting of all structures of the body. All organisms consist of developed cells and groups of cells. In compound organisms, the cells retain the potentialities of single-celled organisms, which, however, they surrender for the benefit of the whole organism. These potentialities are lighted into activity by disease or disorder of the co-ordinating mechanisms constituting the checks on local action for the benefit of the cell-commune or body. Cells, having resumed low embryonic types for the benefit of the body, retain the potentialities of the higher enbryonic, and circumstances may stimulate these, either for the benefit of the body or of the cell itself. This appears in skull and face embryogeny.

The Skull is a development, in part, of the vertebrae and, in part, of dermal or membraneous bones which, as in bony fish and reptiles, formed the protective armor of the skin of the head. As the head end of the spinal cord of the lancelet (amphioxus) grew (Fig. 29) in size the cartilage enclos-

Figure 29
Amphioxus lanceolatus from the left side, about twice natural size (Lankester). The gonadic pouches are seen by transparency through the body-wall; the antrium is expanded so that its floor projects below the metapleural fold; the fin-chambers of the ventral fin are indicated between atriopore and anus. The dark spot at the base of the fifty-second myotome represents the anus.

ing it developed to protect it. This was the earliest appearance of the skull in biologic (phylogeny), as in fetal (ontogeny) evolution. Later, another skull developed in connection with this. The skull, therefore,

has, as Minot remarks, a double origin; or rather, there are two skulls which were originally distinct. In evolution from the lowest fish to the highest mammal, and in human embryonic development, these become united.

The Primary Skull is an extension of the vertebrae which send side-outgrowths to cover the brain, as the backbone covers the spinal cord. This primary skull (Fig. 30,) extended in front of the notochord

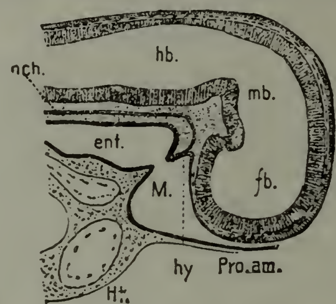


Figure 30

Rabbit embryo of 6 mm (Mihalkovics). Median longitudinal section of the head. The connection between the mouth, *M*, and the pharynx, *ent*, is just established; *nch*, notochord; *hb*, hind-brain; *mb*, mid-brain; *fb*, fore-brain; *pro. am.*, proamnion; *hy*, hypophysis cerebri; *ht*, heart.

(the spinal cord of the human embryo and the permanent spinal cord of the lancelet (amphioxus) or prevertebrate (ascidian). In the lancelet, it gave off two trabeculae cranii, or front skull plates. In man, the primary skull (or chondrocranium) gives off (Fig. 31) two occipital or rear skull plates, and two plates midway between the trabeculae and occipals.

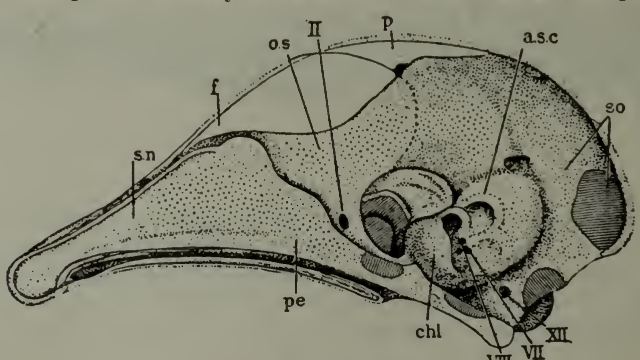


Figure 31

Chondrocranium of an insectivorous mammal (Tatusia). (W. K. Parker).

"In describing this figure in detail," says Minot, "there is one remark to be made, namely, that here we have clearly shown the true

diagnostic mark of a mammalian skull. This mark is the rupture of the side walls, due to the pressure of the large lateral masses of the cerebrum. In front of the auditory capsules, there is a large semi-circular opening, the crown of the arch looking upward and forward. Only the lower half of the wall has thus broken outward; this 'fault' forms the alisphenoid, while the orbitosphenoid (o s), the so-called 'lesser wing,' is many times its size and is continuous over the archways with the cartilage that runs on backward into the supra-occipital region (s o). There is nothing similar to this in that sauropsidian skull which comes nearest to that of the mammal—the skull of the crocodile, while in birds the orbitosphenoids are very small, even when they are most developed, as in struthio, and in that class the alisphenoids almost finish the cranial cavity, being turned inward toward each other, on each side of the back part of the orbital septum. I lay special stress upon this rupture outward of the alisphenoid, and on the fact that the nasal roofs utilize the whole of the huge high-crested intertrabecula, because these are the most distinctive marks of the mammalian skull, and they arise from two things in which the mammal shows its great superiority to even the highest sauropsida, namely, the huge volume of the cerebrum and the tenfold complexity of the nasal labyrinth. A third clear diagnostic sign is seen in this very figure—this is the peculiar development of the antero-inferior part of the oblique auditory capsule, due to the development of the coils of the cochlea. So that, at once, correlated with the sudden expansion, so to speak, of the cerebrum, we have these new and most important improvements in the organs of smell and hearing. At first sight, seeing how large the median bar (intertrabecula) is, with its internasal crest (perpendicular ethmoid and septum nasi—p. e., s. n.), it might be supposed that the mammalian skull was of the high kind, like that seen in many teleostean fishes, lizards and in birds. It is not so, however, but belongs to the low kind, seen in selachians and amphibians, and, like theirs, is hinged on the spine by a pair of occipital condyles. Hence, the eye-balls are kept far apart, instead of coming very near each other, as in most birds, where often nothing but a membraneous fenestra is found between the right and left capsules and their special muscular apparatus. But the face, as well as the skull of the mammal, shows marks of excellence such as are not seen in the sauropsida, even in the higher kinds, as crocodiles and birds. The great development of the nasal organs is correlated with a most remarkable growth of the bones of the upper jaw and the palate to form the 'hard palate.' This is found in rudiment even in the chelonia and in birds, but especially in the crocodilia, where, however, its excessive development—as in certain edentates, (e. g.) myrmecophaga—is not dependent upon or correlated with any great improvement in the organs of smell, but has to do with

the peculiar manner in which these monsters take their prey." These gradually inclose the primitive hearing apparatus, the otocysts (permanent in fish and embryonic in man), and are called periotic capsules.

This primary skull is at first cartilaginous (Fig. 32) as in sharks. In

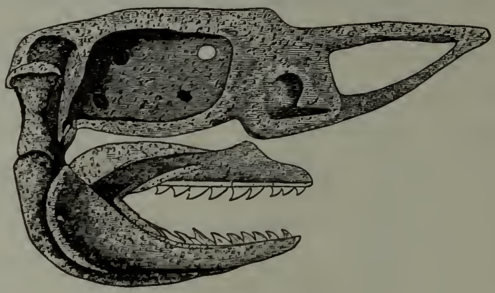


FIGURE 32
The cartilaginous skull of a shark. (Sutton).

the fish, there is a progressive reduction of cartilaginous skull by which its covering over the brain is more and more demonstrated. This reduction leaves an opening on the dorsal side which calls for the space to be filled with dermal bones—frontals, parietals and interparietals. In reptiles and birds, the opening is larger than in fish, and in mammals still larger than in reptiles and birds. Reduction of the cartilages of the branchial skeleton also progresses from the lower to the higher vertebrates.

It is clear from the above description that the evolution of the mammalian skull has depended to a large extent upon the degeneration of the inner skull for its shape and covering, showing the loss or degeneracy of some structures in evolution for the benefit of the organism as a whole. With

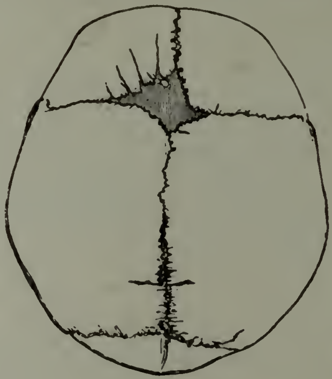


FIGURE 33
Skull showing fontanelles (Gray).

the increase in the size of the brain in phylogeny and in ontogeny, this cartilaginous primary skull becomes insufficient to roof over the brain and gaps result. The fontanelles (Fig. 33) or soft places at the top, sides and back of the head of the new-born are expressions of this failure of the primary skull to cover the gains of the nervous system. This deficiency, while resultant on certain advances in evolution, would be a serious block to further advance or to life itself were it not that the fetal skin of mammals retains an osteogenic function, normal in reptiles, certain edentates and bony fish. This is an instance of the stimulation of cell potentiality for the benefit of the organism as a whole.

SECONDARY SKULL. These cavities were filled by dermal bones (Fig. 34) which, at first merely armor of the skin of the head, later became

FIGURE 34

Lateral view of skull of man forty-five years of age showing wormian bones (Charles A. Parker). This skull is a splendid illustration of the exaggeration of the evolutionary principles or law where certain structures are lost and others gained for the benefit of the organism as a whole. The brain and skull have developed enormously while the bones of the face have lost in proportion. The lime salts intended for the bones of the face and jaws were required to cover the enormously developed brain. The material not being sufficient, one hundred and seventy-two wormian bones were required to fill the deficiencies. They were located at the posterior and lateral regions.

protectors of the nervous system (the brain). The following are representative dermal bones in the embryonic human skulling.

The frontals, which form the chief part of the forehead. The sutures or dovetails of these normally disappear in the adult, so that the forehead seems to be but one bone. This union may not occur (Fig. 35) as in the

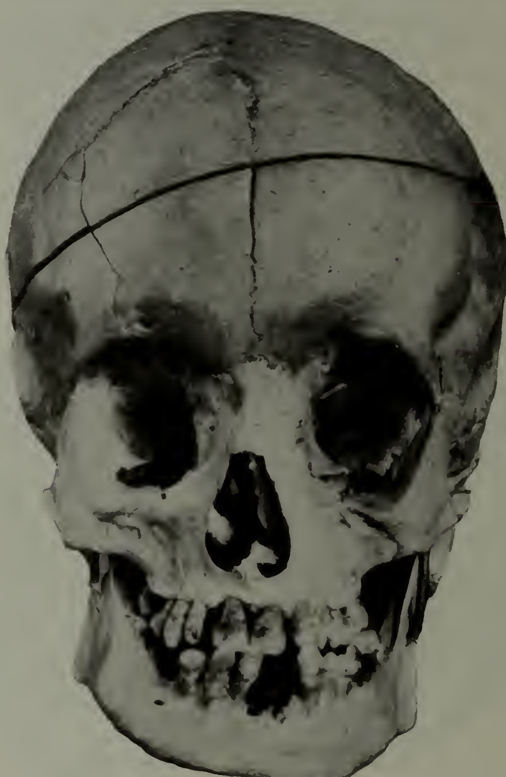


FIGURE 35
Front view of skull showing open suture in center of frontal bones (Charles A. Parker). An imaginary line drawn through the center of the skull, nose and jaws shows marked irregularities in development.

case of the philosopher Kant, who had a frontal suture all his life. The dovetails are replaced by solid bone through a process called synostosis. In the case of the frontal bone, synostosis is normal and in the line of advance. Elsewhere in the skull it expresses defect, giving rise to various cranial states, either absolutely degenerate in type or degenerate in certain races only.

The parietals and interparietals, which are united by synostosis to form the parietals or side bones of the adult human skull.

The nasal bones, which, together with the vomer form the nose.

The pterygoids and palatines.

The maxillaries and premaxillaries which, with the mandibles form the jaws.

The mandibles are in part derived from the chondrocranium.

In the course of evolution, and during the progress of human embryonic development, these bones become fewer by the process of early cartilaginous union or synostosis. The openings in the skull resulting from the deficiencies in the chondrocranium are larger in the sauropsida (birds and reptiles) than in the ichthyopsida (amphibians and fish); in the monotremata (egg-laying mammals) than in the sauropsida; in the marsupials (pouched mammals) than in the monotremata; and in the higher mammals than in the marsupials. Brain development, therefore, depends on the expanding power of the secondary skull formed by the dermal bones. These are degenerate bones, a mere reminiscence of that outer skeleton whereby early fish and reptiles emulated the lobster, whose outer covering has developed into a solid mass. Any check to development causing organism-degeneracy, is exerted on bone development itself, and finally, on the relation to other bones, or dove tailing.

In accordance with the laws of economy of growth, deficiency in one place usually results in increase elsewhere. The brain-protective function of the dermal bones, being later in order of development than their old armor function, is checked by degeneracy in two ways—either the bone does not grow sufficiently in size to unite with its fellows, or this growth occurs for the benefit of the bone alone, and, therefore, union with other bones occurs too early to benefit the organism as a whole. To the factors underlying this latter condition is due the failure of increase in intellect after puberty in the higher apes and the lower human races. These checks likewise tend to nutritional advantage of the older primary skull, whence result irregularities in development that constitutes so many skull stigmata. The sutures sometimes fail to form because sufficient cartilage is not produced to fill the gaps (Fig. 33). These secondary gaps are often filled by new dermal bones called Wormian (named after Claus Worm). Sometimes this deficiency co-exists with too early synostosis elsewhere.

The Phylogeny of the Head and Face, through the anthropoid ape and races of the world to the average type, is extremely interesting. In considering the head bend in man's flight from fish and reptile, to bird and mammal, it will be seen that the most extreme development in the head and face bend are to be observed in animals such as the camel, the cow, the horse and other mammals, including lower monkeys. In the higher apes and animals under domestication, the face, nose and jaws

begin to shorten and degenerate for the benefit of the higher structures such as the brain. This change of the shortening of the nose and face is nicely illustrated in (Fig. 36) where the domestic pig is not required to root for a living. The arrest of the nose, face and jaws is not unlike that

FIGURE 36
Wild boar contrasted with modern domesticated pig (Darwin and after Darwin, Romanes). The marked contrast between these two animals nicely depicts the change in structure owing to use and disuse.

of the human. The law of use and disuse is finely illustrated in these two extremes. The breeding of dogs with a short nose and short upper jaw from the wild wolf-like species are also examples. In natural selection, of course, this process goes on normally and sequentially (Fig. 37) in the

FIGURE 37
Evolution of the face from the anthropoid ape through the lower negro types to the ideal face of the Apollo Belvedere (Camper).

phylogeny of the human race, but it requires a much longer period of time to produce the same results.

The great anatomist and artist, Camper, in his physical observation on the difference of the features of the face considered in profile as the heads of apes, orang-outangs, of negroes and other peoples tracing up to antique heads, says, "you will be astonished to find among my plates two heads of apes, then of a negro and then one of a camel." Dropping the

camel and beginning with the ape we find in order of phylogeny first the gibbon, second, the orang-outang, third, the gorilla so far as hand and foot are concerned, and the chimpanzee so far as brain is concerned, then the pithecanthropus, Neanderthal man, negro from the lower to the higher forms of face, and finally, through different races, until the ideal face of Camper, the Apollo Belvidere, appears.

One of the most interesting stages in connection with Camper's illustration of the evolution of man from the lower animals is seen in the skull of the ape-man (pithecanthropus erectus), discovered by Eugene Dubois in Java in 1891-2. Fig. 38 illustrates the restored skull.

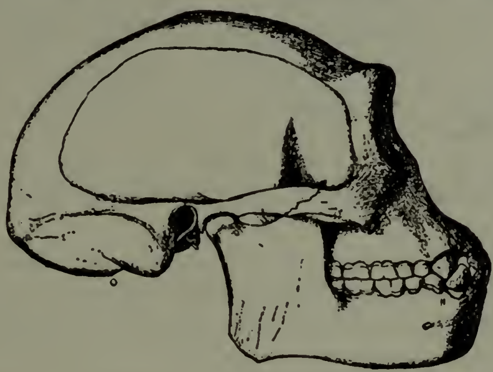


FIGURE 38
Restoration of the skull of the pithecanthropus erectus, about one-fifth natural size (Dubois)

The brain cavity in this type is absolutely larger and, in proportion to the size of the body, much more capacious than in the Simiadae, yet less so than in the Hominidae. Cranial capacity is about two-thirds of the human average. Inclination of the nuchal surface (o) of the occiput is considerably greater than in the Simiadae. Dentition, although retrogressive, is still the human type. The femur is equal in its dimensions to that of man, and, like man's, is adapted for walking in an upright position, higher than the Spy or Neanderthal femur, which are pithecoid.

Of this skull, the upper portion alone is preserved, the line of fracture extending from the glabella backward irregularly to the occiput, which it divides somewhat below the upper nuchal line. The cranium seen from above is an elongated oval in outline, dolichocephalic, and is distinguished from that of other anthropoid apes by its large size and its higher arching in the coronal region. The greatest length from the glabella to the posterior projection of the occiput is one hundred and eighty-five millimeters; the greatest breadth is one hundred and thirty millimeters; and the smallest, behind the orbit, is ninety millimeters. The cranium in its original condi-

tion must have been of somewhat larger dimensions. The upper surface of the skull is without ridges and the sutures all appear to be obliterated.

This dolichocephalic skull, with an index of seventy degrees, is readily distinguished from the brachycephalic orang-outang skull. The absence of the characteristic cranial crests separate it from the dolichocephalic skull of the adult gorilla. In its smooth upper surface and general form it resembles somewhat the chimpanzee skull and still more that of the gibbon (Hylobates).

There are two or three points of interest which seem to indicate that this skull belongs to a type neither man nor ape. The first is the peculiar length and shape of the orbital ridges. If the animal had walked upon all fours, such prominent ridges would have been unnecessary for the protection of the eyes from the sun and violence of all kinds. They are much more prominent and thinner than those of the Neanderthal or Spy skulls. If he had walked continuously upon all fours the occipital protuberance and the superior curved line for the attachment of strong muscles would have been excessively developed. In the place of occipital protuberance appears a depression.

The protrusion of the face and jaws, from the perpendicular line, is quite marked. The lower jaw is more human than ape-like, since it possesses a well developed chin. The teeth are deeply set in the jaw, the crowns are short while the roots greatly diverge.

Through the kindness of Dr. Whitney of Honolulu, Hawaii, I have in my possession an Hawaiian skull with like characteristics to the pithecanthropus erectus. It is dolichocephalic, like the illustration, and has large orbital ridges.

Ontogeny

His distinguished three periods in the development of the unborn child. First, the product of conception during the first two weeks is called the ovum; second, from the third to the fifth week, the embryo; third, after the fifth week, the fetus. Until 1907, the earliest human ova was that described by Peters. In that year, J. H. Teacher, of Glasgow, Scotland, discovered the youngest known embryo. It antedates Peters' classical fifteen-day ovum by from one to three days. These can only be differentiated with the aid of the microscope. Fig. 39 represents the first

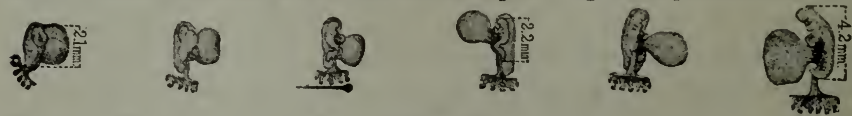


Figure 39

Early embryos (His). In the last illustration, which is at about the third week, the head bend begins.

stage, that of the ovum from the primitive streak to that of an ovum four and two-tenths millimeters in length. In all of these illustrations, there is no head bend. This represents the fish and reptilian stage. In the last illustration, however, there is a slight head bend.

Beginning with the third week (Fig. 40), the head bend is quite

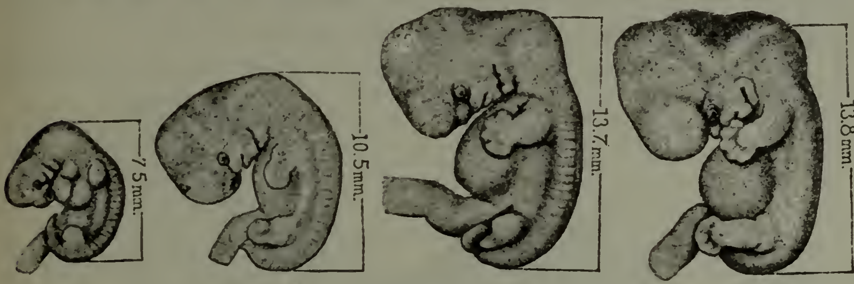


FIGURE 40
Embryos from the fourth to the fifth week (His). In these illustrations the head bend is most marked.

marked which gradually increases as development goes on; the gill slits are well developed. In the embryonal period, the formation of the medullary groove and canal takes place. The abdominal pedicle is seem coming off from the tail end of the embryo. The embryo at this period is made up, in great part, by the yolk-sac. A little later, the double heart, (the fish stage) may be noticed, while the cerebral and optic vesicles, as well as the visceral arches and clefts appear. At the end of the third week, the limbs begin to make their appearance as small buds, not unlike those of the frog. At the fourth week, a great increase in the size of the embryo takes place. The eyes, nasal pits, maxillary processes, ears and nose are now visible. The oral fossa has assumed a somewhat irregular shape. A little later, the maxillary and globular processes unite and form the nasal pits, separating them from the mouth cavity. It is at this period (Fig. 41)

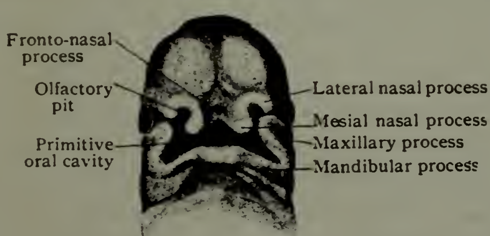


FIGURE 41
Fetus showing development of the face and mouth at the twenty-seventh day (Piersol). It is at this period that on account of an unstable nervous system, the tissues are not properly formed, resulting in cleft palate and harelip.

in fetal development, owing to disturbed nutrition, that the globular processes occasionally fail to unite, on one or both sides, producing harelip or cleft palate. At about the fourth week, it is impossible to determine from the appearance whether the fetus be that of fish, reptile, bird or human. The fetus is still markedly bent upon itself. The visceral arches and clefts are the most prominent characteristics of its cephalic region, and indicate the fish-like character in its evolution.

At the end of the second month (Fig. 42), the brain begins to develop,

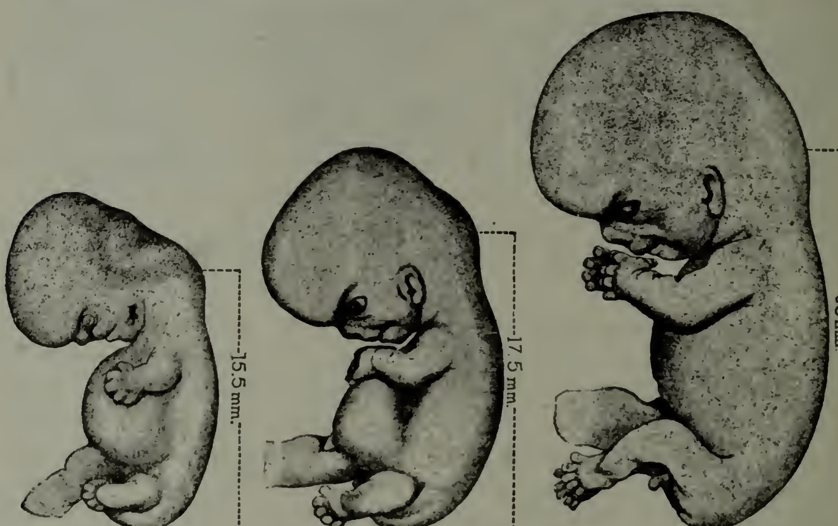


FIGURE 42
Embryos from the second month (His). It will be noted in these illustrations that the head is gradually assuming the upright position.

the head becomes considerably larger and more erect, and the fetus has passed its quadruped stage. The nose, mouth and ears are less prominent, and the limbs are more developed. The external genitalia are beginning to develop. At the end of the third month, the fetus and its entire product are about the size of the fist. Ossification has made its appearance in some of the bones. The fingers and toes are observable. Sex differentiation is now possible, but is not definitely revealed until the end of the fourth month. At the fifth month, the skin has become less transparent and the entire body is covered with downy hair. At the sixth month, fat begins to deposit. The head becomes more erect and assumes the position of the upright vertebrate. At the seventh month, there is very little change. At the eighth month, the skin is red and wrinkled. At the ninth month, the wrinkles disappear and the fetus has arrived at its full development.

In the early stages of development, the skull is cartilaginous, like that of sharks and allied fish (Fig. 32), whose skulls always consist of cartilage impregnated with lime salts. In bony fish and amphibians, the overlying bones gradually bring about absorption of the cartilage in places. According to Sutton, much of it exists through the life-time of the animal. In the skulls of even the highest adult mammals, there are traces of this important matrix-tissue, characteristic of embryonic states.

Embryology of the Human Skull. The embryogenic (developmental) history of every mammalian skull is the same. If all the investing tissue be removed from the skull of a human embryo at the tenth week of intrauterine life, the base will resemble Fig. 43, A B C.

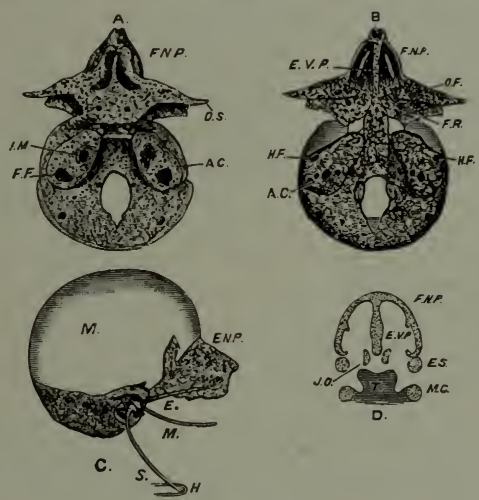


Figure 43

Four views of the human skull in its cartilaginous condition (Sutton). *A*, the skull viewed from above; *F N P*, fronto-nasal plate; *O S*, orbito-sphenoid; *A C*, auditory capsules; *B*, the same skull viewed from below; *C*, side view; *F N P*, fronto-nasal plate; *E*, Eustachian cartilage; *M*, Meckel's cartilage; *S*, styloid cartilage; *D*, section through the facial region of the same skull.

Face, nose, jaws and base of the skull are cartilaginous in character. The primordial chondrocranium is excellently shown in these illustrations. This illustration shows the relationship between the human skull and the development of the chondrocranium of the lower vertebrates, especially the insectivorous mammals, pointed out by Minot in the phylogeny of the skull. Minot says, "the skull then is developed from two distinct skeletons, the primary cartilaginous skeleton, which in the higher forms becomes partly ossified, and the second skeleton composed of dermal bones. The cartilaginous stage is made up of separate cartilages, but no definite line

can be drawn between a previous stage and the following. The dermal bones begin to develop before the cartilages ossify, and are present in cartilaginous fish, hence they must be considered older than the bones replacing cartilage. The replacement of cartilage by bone is very slow and never becomes complete."

Owing to the head bend of the embryo, the oral invagination, or mouth cavity, is brought between the forebrain and the heart upon the ventral surface. This is its permanent position in sharks. Through the vertebrate series, if the development of an amniote (reptiles, birds and mammals) be followed, an increase occurs in the region of the olfactory and oral invaginations, in consequence of which it projects more and more, and by a further throwing of the whole head upward (Fig. 42), the face is brought forward and projects in front of the brain.

In the development of the skull, the chondrocranium is the first stage, formation of the dermal bones the second, and ossification of the primordial chondrocranium the third. The brain now passes through the different states of development described in Chapter III (Fig. 23), from fish to reptile and from bird to mammal. In this flight, the bones develop about the brain and pass through these stages (Figs. 44 and 45). In this fine collection and arrangement the student can readily trace the ontogeny of development. At the third month, calcification begins, as previously stated. Ossification commences at the center of each bone and proceeds toward the periphery. The bones are separated before birth by membraneous intervals in which deposits of bone cells are deficient. The fetus is beginning to assume human characteristics by the anterior and posterior development. The gradual higher anterior development of the brain and skull is also quite noticeable.

The human skull and that of the higher ape resemble each other at birth. From this period on (Fig. 16), the growth of man is centered in brain development. The animal type branches off to follow animal and physical instincts. The perceptive faculties of man are centered in the forebrain.

There are still non-ossific remains of the membrane as observed in all the skulls up to and including three and one-half years of age. The fontanelles usually close during the first year. As will be observed, however, when there is a large deficiency, or when the bone deposits are slow, a much longer time is required. Not infrequently, these gaps are not filled by the original bone from the first centers of ossification. When this is the case, smaller bones (wormian) fill the deficiency. These small bones often develop from special centers of ossification. As has been shown in phylogeny, the cartilaginous primary skull, being insufficient to cover the brain resulting in gaps, the osteogenic function, normal in certain edentates,

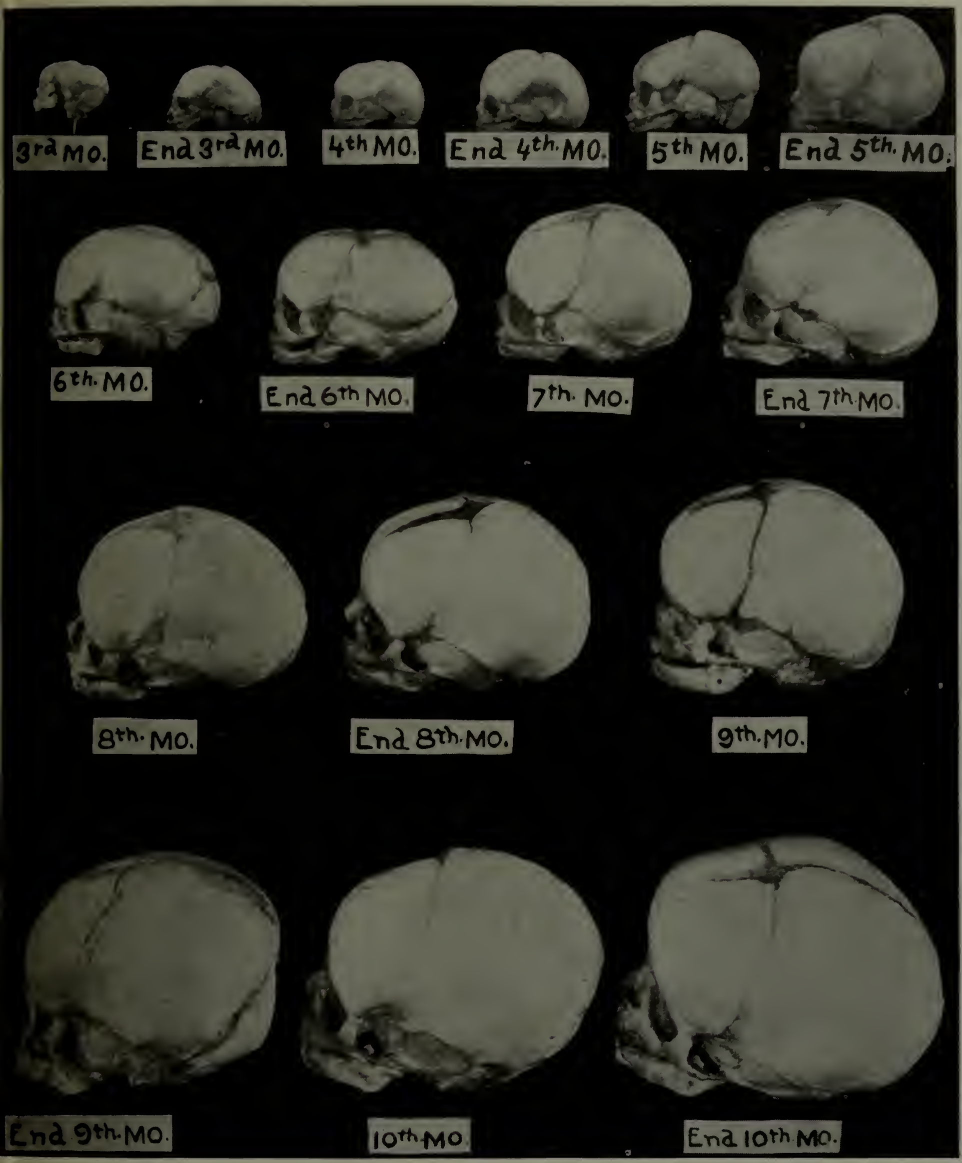


FIGURE 44

Fetal skulls in their evolution from the third month to birth (Charles Ward). The gradual development of the anterior part of the brain in phylogeny is here noticed. The changes are rapidly taking place in face and jaws.

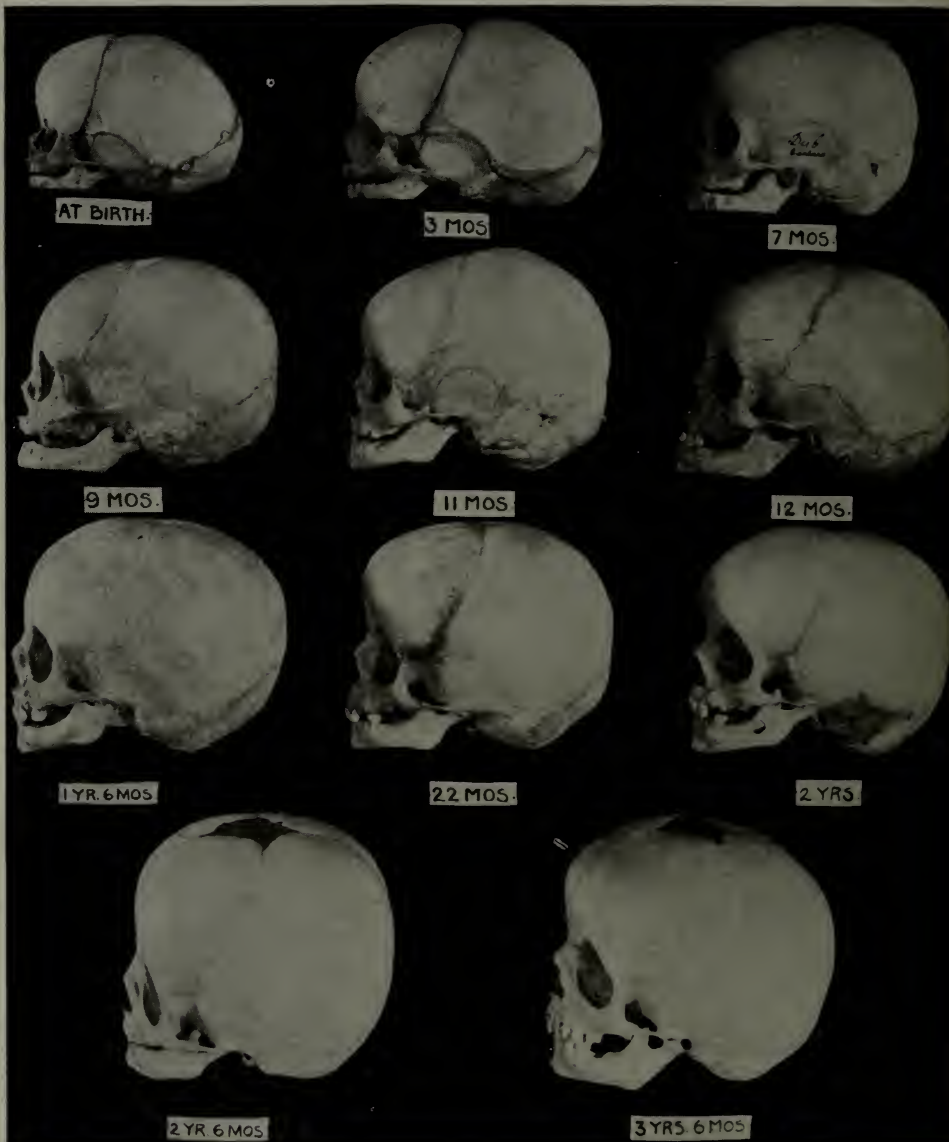


FIGURE 45

Skulls in their evolution from birth to three years and six months (Charles Ward). Showing still further evolution in frontal and face development. Arrests and excessive development of all the structures are outlined at this early period.

reptiles and bony fish, furnishes material (wormian bones) to fill these cavities. These bones are more frequently found in degenerates than elsewhere. Lombroso and Ferrero have recorded a number of cases observed in the crania of harlots and criminals. I have frequently seen these bones in degenerates, especially in those skulls, larger than normal, of which the hydrocephalic is the type. While these bones may develop in seemingly normal individuals, they occur with an unstable nervous system. Thus, for example, the hydrocephalic brains of Sir Walter Scott and Cuvier were repaired by an increased barren ependymal tissue. Healed-up hydrocephalous is often thus attended by a seeming normality which co-exists with wormian bones.

The man whose skull is illustrated in Fig. 34 was a familiar character on the streets of Chicago for many years. He was forty-five years of age when he died, had always been a cripple with imperfectly developed and mis-shapen limbs. He wheeled himself about the streets in a little cart selling lead pencils. The history and description of this man by Hektoen and Parker are of unusual interest. The arrest of development of the face and the large number of wormian bones (of which there were one-hundred and seventy-two), together with the physical mal-development of other parts of the body, show a marked, unstable nervous system.

The Processes of Skull Growth are far from simple. Skull and brain are interdependent. The cranial cavity has a much larger volume in the child than the adult. That the entire roof and a large part of the sides of the skull being composed of membraneous or dermal bones not in contact with each other, at birth, give an excellent opportunity for any change in skull or brain development. Even the skull base, at this time, has but little ossified cartilage. The general changes which take place in post-natal skull development, are first, a relative elongation of the anterior portion, and second, relative increase in the depth of the superior maxillae.

If, in a child's skull, a division be made between the central points of the occipitals, the base of the skull will be divided into two portions of equal length. The frontal portion of a similar division in an adult is much greater than the back portion. Froriep has shown the proportion between the two is 5 to 3 in the adult, as against 3 to 3 in the child. This increase of the skull's frontal portion marks a rapid growth, associated with a relative increase in the dorso-ventral measurements of the superior maxillae.

Development of the Face depends upon enlargement and fusion of the mouth and nose cavities, and upon later partial separation of nose and mouth and nose cavities, leaving the posterior nose open. It depends further upon the growth and specialization of the face region, of which

elongation is the most prominent feature, and, finally, upon the development of a prominent nose. When the medullary tube of the notochord enlarges to form the brain, the end of the head bends over to make room for that enlargement (Fig. 30). The bending of the head carried the mouth plate, which is to be the mouth, over to the front of the head. What develops the mouth cavity is the growth of the brain and the increase in size of the heart cavity, which expand to the front, leaving the mouth cavity between them. The mouth cavity represents two gill slits united in the front line. The nose (Fig. 46) is formed from the two olfactory plates situated just

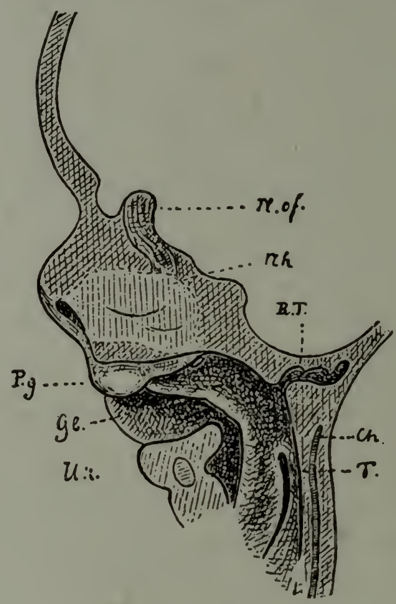


Figure 46

Reconstruction of the face (His). Embryo Sch. N. *of*, olfactory nerve; *Nn*, nasal cavity; *R T*, Rathke's pocket; *Ch*, notochord; *T*, tonsil; *Pg*, processus globularis; *Gl*, palate anlage; *Uk*, mandible.

in front of the mouth and in contact with the forebrain. These olfactory plates grow in size by the increase in tissue and the resulting pits pass away from the brain. At first these pits, although separated by what is called the nasal process, communicated freely with the mouth. The nasal process includes the origin of the future nose and of the future intermaxillary region of the upper lip.

The nose and face of the lower vertebrates extend a considerable distance in front of the brain. This frontal development of the face is retained to a less and less extent as evolution progresses to the pithecoid

and anthropoid apes. In man, the face, including the nose, is quite short. The brain and skull cap cover the face.

Struggles for existence between the various organs implies the existence of potentialities, which not only are inherited, but pass through periods when the newer type has to compete with organs already existing. There must, therefore, be the usual excess of material for growth, like that which occurs in fractures, where provisional callus is thrown out. This needful excess is obtained at the expense of other organs. If the utilization of disappearing fetal organs suffices to provide this, defects do not occur. If not, they occur along the line of least resistance, which may be the higher or lower gains. Thus, when the brain and skull do not receive the normal amount of nourishment, they remain undeveloped and the face and jaws become excessively developed. On the other hand, if the brain and skull receive the most nourishment, they become excessively developed and the face and jaws arrested. Fig. 34 shows an exaggeration of this law, owing to an unstable nervous system. The face, which was once larger than the cranium in this particular illustration, is very small as compared to the skull. The face, jaws and teeth become markedly deformed in every particular.

Nose Development. The nasal pits proper are developed by the upgrowth of the ectoderm and mesoderm around the olfactory plate. The upgrowth takes place on the medial, upper and lateral side of each plate, and hence forms two pits with a partition (the future nasal septum) between them. These nasal pits communicate along their whole lower side directly with the mouth cavity. The nasal pit is at first very shallow. In their growth, there are two principal changes; first, growth of the tissues occurs around the olfactory plate, and then the pits migrate away from the brain. The nasal pits are separated by a projecting mass of tissue called the nasal process, which includes the partition between the two nasal chambers, the outline of the future nose and of the future intermaxillary region of the upper lip. The maxillary extends between the mouth and eye toward the nasal pit, and by joining the rounded end of the nasal process, begins the separation of the nasal and buccal chambers and completes the upper border of the mouth. As development proceeds, the lateral ridge grows forward and covers in the nasal pit from the side forming the outline of the wing of the adult nose. These are now two external nares. The nasal chambers enlarge as the whole face enlarges and occupy an increasing space opening widely into the mouth cavity above the palate shelf. It is from the nasal pit proper that the so-called labyrinth of the nose is formed. The development of the labyrinth begins with the appearance (during the third month of embryonic life) of three projec ting folds on the lateral wall of each nasal chamber. These folds are the upper, middle and lower

turbinal folds. They very early contain cartilage. The formation of labyrinth advances by formation of outgrowths, which become the ethmoidal sinuses, by the appearance during the sixth month of the antrum of Highmorii, or expansion of the nasal cavity into the region of the superior maxillary, and finally, by evaginations to form the sphenoidal and frontal sinuses, which, however, do not arise in man until after birth. The separation of the olfactory plate from the brain does not take place until the olfactory ganglion develops from the epithelium. The fibers lengthen, the olfactory and neural epithelium separate and, finally, the osseous cribiform plate is developed between them.

The external nose develops toward the end of the second month of embryonic life by a growth of the nasal process. It is at first short and broad, having (at the third month of embryonic life) very nearly the shape which is permanent in certain negro races. The external nares and wings of the nose are carried forward with a general nasal growth.

As soon as the external nose is separated from the mouth, there is a partition between the nasal pits and the mouth. The partition in which the intermaxillary bone is differentiated later is supplemented by another partition, the true palate, which shuts off the upper part of the mouth cavity from the lower, thus adding the upper part to the nose chambers. The palate is a secondary structure which divides the mouth into an upper respiratory passage and a lower lingual or digestive. The palate arises as two shelf-like growths of the inner side of each maxillary process, and is completed by the union of the two shelves in the median line. These so arch as to descend a certain distance into the pharynx. In the pharynx, however, their growth is arrested, though they may be still recognized in the adult. In the region of the tongue which includes more than the primitive mouth cavity, the palate shelves continue growing. At first, they project obliquely downward toward the floor of the mouth and the tongue, rising between, seems in sections, which pass through the internal nares, to be about to join the internasal septum. As the lower jaw grows, the floor of the mouth is lowered and the tongue is thus brought further away from the internasal septum. At the same time, the palate shelves take a horizontal position and pass toward one another above the tongue and below the nasal septum to meet in the middle line where they unite. From their original position, the shelves necessarily meet in front, toward the lip first and unite behind, toward the pharynx later. In the human embryo, union begins at eight weeks and by nine weeks is completed for the region of the future hard palate, and by eleven weeks for soft also. The palate shelves extend back across the second and third branchial arches. The uvula appears during the latter half of the third month as a projection of the border of the soft palate. Soon after the palatal shelves have united

with one another, the nasal septum unites with the palate also, and thereby the permanent or adult relations of the cavities are established.

THE JAWS and surrounding tissues are developed from the three germinal layers of the blastederm in the following manner: From the epiblast, the epithelial lining of the cavity of the mouth and enamel of the teeth; from the mesoblast the jaws, blood vessels, lymphatics, connective tissue and dentine of the teeth; from the hypoblast, the epithelial lining of the alimentary canal beyond the oral cavity.

The first indication of the formation of the oral cavity is seen very early in the life history of the embryo. The superior maxilla arises from three separate points; on either side of the embryonic head a process springs from the first pharyngeal arch. The processes pass downward and forward and unite with the sides of the nasal process. From the frontal prominence, the third process, the incisive, grows downward and fills in the space between the ends of the two preceding processes. By a union of these three processes, the superior maxillae are completed. The inferior maxilla is formed by buds growing from the first pharyngeal arch; these buds grow rapidly until union occurs at the median line. The central portion of the arch thus formed, very soon after the union of the lateral processes, becomes differentiated into a cartilaginous cord or band, which serves to strengthen the embryonic jaw. This is Meckel's cartilage. It is formed of two parts rising from the mallei of the ears and traversing both sides of the embryonic jaw to the point of union. While the jaw bone is forming, Meckel's cartilage disappears, by absorption; some authorities believe it becomes ossified, forming part of the inferior maxilla.

The face and jaws are lengthened by the development of the first and second dentition and also by the length in development of the rami. The alveolar processes lengthen to accomodate the jaws and the roots of the teeth. The roots and crowns of the temporary teeth, when in place, bring the jaws quite a distance apart. This lengthening of the jaws is considerably increased when the permanent teeth are in place. If, from any cause, the rami are excessively developed in length, the desire to bring the jaws together is restricted. The tendency is for the alveolar processes to develop upward on the lower jaw and downward on the upper jaw until the teeth occlude.

Modification of the human face backward from the vertebrate type excellently illustrates degeneracy of series of related structures for the benefit of the organism as a whole. The progress of development of the vertebral face is checked in man because, as Minot remarks, the upright position renders it unnecessary to bend the head as in quadrupeds, and also because the enormous cerebral development requires enlargement of the brain cavity. This has taken place by extending the cavity over

the nose region as well as by enlarging the whole skull. It is likewise because development of the face is arrested at an embryonic stage. The production of a long snout is really an advance of development, which does not occur in man.

Types of Skull. Upon variation in the dermal bones depend, not only the race variations in skull and jaw types, but also variations produced by agencies acting on the individual during the periods of stress and by the degenerative influences on parents and child. Contrasting the human face, developed with that of animals with a long snout, apes and the lower negro type (Fig. 37), it will be seen that the jaws grow smaller in size and weight as the anterior brain development increases. Ontogeny, in the

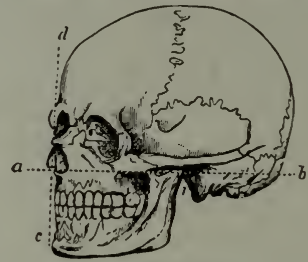


Figure 47
Skull showing the jaws and face on the perpendicular line (original). This is the dividing line where normal development ceases and the pathologic begins in man's evolution.

development of the human head, is now at the facial angle (Fig. 47), as represented in the last number of (Fig. 37) the Apollo Belvidere.

Craniologists generally assume two prominent skull types, dolichocephalous (Fig. 48), or long horizontally, that is antero-posteriorly, with long, narrow protruding jaws and the brachycephalous (Fig. 49), or approxi-

Figure 48
Dolichocephaly (Greves).

Figure 49
Brachycephaly (Greves).

mately round horizontally, with broad, square, non-protruding jaws. The two types are determined by the so-called cephalic index, which is

determined by the relation of the antero-posterior diameter (measured from the glabella to the farthest point of the occiput) to the transverse diameter from side to side. The former being taken at one hundred, the latter will range from about sixty to ninety-five or even more, increasing with the greater degree of brachycephaly and *vice versa.* Excluding artificial deformation, the extremes appear to lie between sixty-one and nine one-hundredths (Fijian measured by Flower) and ninety-eight and twenty-one one-hundredths (a Mongolian described by Huxley).

In the evolution of races, both extremes tend gradually to approach the medium type of head, or mesaticephaly, with gradual recession of the jaws.

Summary

Phylogeny

The head and face development from the single, as well as compound cell organism, is the most interesting of all the structures of the body.

The bony framework of the head is developed partly from the vertebrae and partly from the dermal bones, which forms the armor of the skin, and acts as a protection for the brain. The earliest appearance of the skull in biology is seen in the lancelet, whose head end of the spinal cord grew in size and the cartilage correspondingly developed to protect it. Later, another skull developed from the dermal bones, so, according to Minot, there are really two skulls, originally separate, which united during the process of evolution.

The primary skull, or chondrocranium, is a vertebral extension and sends outgrowths to cover the brain. Owing to brain increase, the chondrocranium is not able to cover it, hence gaps result, called fontanelles, which are larger and larger, the higher one goes in the scale of life. These gaps are filled by dermal bones and, during the process of ossification, the union becomes so indistinct as to appear as but a single bone. Sometimes this union does not occur at all, and a suture remains during the entire life of the individual. Such openings are a mark of degeneracy, and constitute a reversion to the lower mammalian type.

In man's development through fish, reptile, bird and mammal stages, extremes are observed and man's upright position is really a degeneration. Owing to disuse, man's face, nose and jaws are shortened and degenerate for the benefit of the brain. This is nicely illustrated by Camper in his profile study of apes, orang-outangs, negroes, to the Apollo Belvidere.

Ontogeny

According to His, there are three periods in uterine development; first, the product of the first two weeks is known as the ovum; from the

third to fifth week, the embryo; third, after the fifth week, the fetus. Up to the beginning of the second month of fetal life, no distinction can be observed between fish, reptile, bird or mammal. At the close of the second month, however, the brain begins to develop and the human fetus passes from the quadruped stage.

In fetal skull development, the chondrocranium is the first stage; dermal bone growth, the second, and ossification of the primary or chondrocranium, the third.

The skull of man and that of the higher apes resemble each other at birth, but after this period man's growth is dependent upon his brain growth.

During healthy human skull growth, the fontanelles usually close during the first year, but sometimes these are not filled by the original dermal bones and the osteogenic function furnishes the material. This material is called Wormian bones after Claus Worm. This is a degenerate condition often observed with hydrocephalous.

Face development depends upon the growth and union of the mouth and nose cavities, their partial separation, elongation and the formation of a prominent nose.

In the process of development, struggles for existence occur between the skull and brain on the one hand and the face and jaws upon the other. During this struggle, if the face and jaws receive the most nourishment, they become excessively developed, while the brain and skull remain undeveloped and *vice versa.*

The external nose develops at the second month of fetal life and is short and broad. As soon as it separates from the mouth, a partition arises between the nasal pits and the mouth. The intermaxillary bone contributes another partition, the palate, which divides the mouth into the respiratory passage and the digestive.

The oral cavity develops early in embryonic life. The superior maxilla is formed from a union of three processes. The inferior maxilla from buds from the first pharyngeal arch.

The face and jaws elongate by the development of the deciduous and permanent teeth and also by the length of the rami. The alveolar processes also lengthen to aid the jaws and roots of the teeth.

There are two generally recognized skull types, the dolichocephalic, or long head with long, narrow jaws and the brachycephalic, or round head with broad, square jaws. However, owing to intermixture of races, intermarriage, environment, these two types are slowly approaching the mesaticephalic or medium type, with jaw recession.

Chapter VIII

PERIODS OF STRESS

MAN'S embryonic history essentially involves that of the invertebrates as well as the lower vertebrates. In his embryo differentiation, as we have seen, structures are developed and others sacrificed for the benefit of the organism as a whole. This economy of growth likewise governs the relation of the organs to each other.

Development of the organism involves changes in which certain parts, some organs for instance, cease to advance after certain periods, while others assume a relatively greater importance. Some of the functions, possessed at the beginning by certain cells, are lost, and they develop in one direction only. These changes, while they fit the cell to perform its specific purpose in the organism, involve a loss of power of independent existence and are, in this respect, expressions of excessive and arrested development respectively, either of which constitutes degeneration.

Similarly, certain organs well developed in early life, undergo arrest of development or degenerate as the organism advances, cease to grow and even disappear. The organism as a whole is itself limited in its periods of growth, for, after it has reached a certain age, it ceases to increase in size and remains practically stationary throughout life. Growth of the organism is regulated by the activity of certain ductless glands, the pituitary gland for instance. Whatever organ may check or stimulate growth, it is certain that when it fails and an undue or under size is attained, pathologic conditions result of excessive and arrested development.

During man's development from the primitive cell, certain periods occur in which unfavorable influences so act as to occasion a stress or struggle. These are known as periods of stress. A period of stress is when a new function disturbs the physiologic balance previously existing. Stress results from the organism having to accomodate itself to the disturbance. An example is the onset of menstruation in the girl and its disappearance in the woman. The stress may act on the organism, as a whole, or on a particular part. If the stress be upon the organism as a whole, the organs least able to bear it show its effects most clearly. Thus, partly developed organs, whose functions are as yet imperfectly established, are likely to be checked entirely in their development or to take an abnormal course. The organs of greatest importance may secure nourishment and nervous force at the expense of others, so that there is a struggle for existence between the different organs. If the stress fall on one part, local changes

may result in arrested or excessive development, that is, in degeneration of the particular organ. These changes will be more marked if the stress occur during the plastic state of the affected organ, but on the other hand, under such conditions reparative changes are apt to be correspondingly active.

Degenerative Influences. Three kinds of unfavorable influences affect the organism or its parts, viz:—mechanic, toxic and nutritive.

Mechanic Influences are frequently operative in changing the direction of the development of certain organs. Thus the weight of the body may operate in certain infants producing deformities like bow legs. Mechanic influences are often effective in changing the shape of the jaws and teeth. A mechanic influence, ordinarily insufficient to produce an abnormality, may do so at a period of stress when it is favored by weakness from other causes.

Toxic Influences. The germ of disease may be inherited, or general nutrition of the fetus may be so checked in development that the child inherits a predisposition to disease.

Through this check to fetal development, the phagocytes, or white blood cells, become so weakened that they are unable to devour fetal structures, as useless to man as the tadpole's tail (which it devours) is useless to the developed frog. This power being weakened, the organs which form antitoxins (or protective tonics against disease), from lack of development fail to perform their function. For this reason, in the degenerate, many infections and contagions assume their old destructive type.

The influence of these disorders in the parent may result in the bony, mal-development shown to occur in animals by Charrin and Gley, and in man, by Coolidge. The facial bones, jaws and teeth are peculiarly liable to be thus affected. Though the effect of the disease on the parent be but temporary, the child's development may be checked as to higher tendencies. Thus mothers have borne moral imbeciles, epileptics or lunatics after a pregnancy during which they were attacked by a contagious disease, albeit the children of subsequent and previous pregnancies were normal. Marked deformities were the result.

The children of pregnancies previous to the one complicated by the contagious disease or tonic elements may be healthy, while those of subsequent pregnancies are defective. Any contagious or infectious disease may not interfere temporarily with the bodily strength, but may produce complete change in the parent's system, extending even to the highest acquirement of man.

Nutritive Influences (the most common) take place in two directions: either in an excess of nutritive material which, when the proper conditions are present, leads to excessive development (Fig. 34, skull) of

the affected parts, or conditions are unfavorable to nutrition and arrested development also (Fig. 34, face and jaws) occurs. The conditions unfavorable to nutrition are, lack of nutritive material, lack of proper assimilation and lack of proper nervous influences to stimulate and control nutrition.

Periods of stress during development are called periods of evolution; those after maturity, periods of involution. At these periods of stress, development of the nervous system may be strained and produce arrests or excesses in development or degenerations.

Arrests or excesses occurring at any period during development underlie all so-called deformities of the body. These are often reversions which simulate features of the adult fish, reptile, bird and mammal, characteristic of the fetal stages through which man, reproducing his phylogeny in his ontogeny, passes. The structures most prone to such degenerations are the head, face, nose, jaws and teeth, since these features are still in process of evolution and they are therefore peculiarly susceptible to the law of economy of growth in the struggle for existence between organs. This struggle between organs occurs among animals as well as in man. Wild animals in captivity, and others through domestication (change of environment and food), present changes in structures similar to those of man.

Structures undergoing degeneration are, because of greater or lessened blood supply, more liable to disease than those more highly evolved. Marked illustrations of this may be found in irregularities of the teeth, in disharmony in jaw development where the teeth are not being lost fast enough for the receding jaws, in interstitial gingivitis, and in excesses and arrests of development of the structures of the nose and sinuses.

Periods of Stress. Struggles for existence on the part of the different organs and systems of the body are most ardent during periods of evolution and involution. During development in utero, during the first dentition, during the second dentition (often as late as the thirteenth year), during puberty and adolescence (fourteen to twenty-five), during the climacteric (forty to sixty), when uterine involution occurs in woman and prostatic involution in man, and finally, during senility (about sixty and upwards), mental or physical defects may occur, a congenital tendency to which has remained latent until this period of stress.

When systemic balance, the rational attendant of evolution, is disturbed by change in environment, the organs do not pursue their normal growth. Such disturbances are most apt to occur during periods of stress, because of the varying relations of different organs.

The first intrauterine period of stress occurs during the early third of embryonic life, when the embryo rapidly passes through the stages which correspond to the adult fish, reptile, bird and mammal types and

assumes the form of the future human being. In this period, the most marked deformities occur, and monstrosities are produced which often result in the death of the fetus. Such disturbances in development are likely to affect most powerfully, structures in which evolution is variable. This influence must strongly affect nutrition of the dermal bone elements of the skull, face, nose and jaws, and hence must affect the teeth. Its results are not always obvious until the later periods of stress.

A check on or an excess of the growth of the higher organs of the nervous system frequently results in impairment of the mental faculties in that any of the degenerations may occur. In these cases, the brain remains in the stage characteristic of the common simian ancestor, or the higher faculties may attain only the development of primitive races, in whom emotional control and ethical ideas are insufficient to meet the exigences of civilized states. Together with and dependent upon this cerebral mal-development, deformities of all the structures of the body, including the head, face, nose, jaws and teeth occur.

In the latter part of intrauterine life, imperfect development of the nervous system may be accompanied by a premature growth of the teeth, so that they may erupt before or at birth. Prenatal or congenital teeth often accompany imperfect development of other organs.

The intrauterine development of man and ape is so similar that they congenitally resemble each other more closely than do the developed adults. The fetus of the ape resembles an adult more nearly than the adult ape resembles the adult man. In extrauterine development a marked contrast exists. The ape passes through a short infancy to a condition of fixity from which there is no further development.

Periods of stress are furnished by the different periods of embryonic as well as by those of extrauterine development. Even sex is determined by conditions of stress after a certain period. Poor maternal nutrition will determine an excess of males, while good will determine an excess of females. Arrests at certain periods of intrauterine life will produce prematurely senile states; since, as already stated, there is a period of intrauterine life during which the fetus wavers between the senile appearance of adult anthropoid apes and that of mankind in youth. This intrauterine stress may be an expression of the general nervous exhaustion of the mother, which, first affecting the check influences of the central nervous system, finally leads to unchecked excessive functionation of the part of the local nervous systems of the various organs, secondarily leading to their exhaustion. In consequence, the mother is unable either to manufacture proper elements of nutrition or to properly excrete waste material. The fetus, thereby starved and poisoned, fails to pass through the periods of stress in a complete, well-balanced manner. The stress in

these periods is naturally strongest on those structures which are transitory and variable in type. This influence may, furthermore, be exerted on the fetus by virtue of stress, mental or otherwise, in the mother. The human fetus exhibits, as elsewhere shown, very decided re-action to sensory impressions on the mother.

The Fetal Periods of Stress in the human organism deserving most attention are those occurring at sex differentiation and at the senile or simian period (Fig. 50) of intrauterine life, about four and one-half

Figure 50

Fetus, fourth month (original). This is the senile or simian type. An arrest of development at the first period of stress. The wrinkled face; the hairy body; the arrest of the ear and the nose; the flabby skin; the long, slender fingers; the arrest of muscles; the long flat feet show the permanent arrests of children born of parents with unstable nervous systems.

months after conception. Three conditions, infantilism, masculinism, and femininism, and occasionally a mixed state, result from arrest of development before, at, and after sex differentiation in intrauterine life. As sex organs and sex nerves are differentiated before the sexual appetite appears, the mental side of sex can be determined only in extrauterine life. Practically all three conditions mentioned are arrested development of the promise of the child type.

As the female type most nearly approximates, from the stand-point of bodily and nervous development, the promise of the child type, checks or excesses in its development result in masculinism. In the first the female has proceeded so far in development as to have female organs and their functions, while retaining traces of the lower male type. In the second, the male has proceeded along the line of evolution toward the female type, but ere sex has been fully differentiated, further development is checked and the male type is finally assumed as the predominant one. Both sexes proceed from an indifferent type, nearly resembling the hermaphroditic type found in the lower animals. Arrest of development takes place at any point in the embryogeny. Arrest at these periods of stress, through any process which retards development, peculiarly influences the development of the child after birth. When due to syphilitic conditions, which exert a severe strain on development, the child readily succumbs to the infections and contagions. It also produces early senile stress in the child so important as regards the head, face, nose, jaws and teeth. Forces exerted during the senile period of stress play a large part in determining precocity and its product premature senility, with osseous and other consequences. Neurasthenia in the parent may result in bony arrest or excess of development, such as is shown in macro- and microcephalic heads. The head, facial bones, nose, jaws and teeth are peculiarly thus affected. If the effect of disease on the parent be but temporary, one child's development may be checked as to higher tendencies while another may show no such defect.

The power of passing through the fetal periods of stress depends on the condition of the fetal organism at the time of the periods of stress. This condition depends partly on inherited factors and partly on maternal conditions. Defect in either, at this period of stress, may so affect the struggle for existence between the fetal organs that reversionary conditions gain the ascendancy. This is true of such conditions as cyclopia, in which the pineal body becomes an actual eye, as in certain lizards, while the paired embryonic eyes in man disappear. Similar stress at the proper period causes arrested brain types in idiots, at the stages resembling the brains of sauropsidae (bird and reptilian types).

To a certain extent, periods of stress resemble ancestral stages. Moreover, when there is a recapitulation of ancestral stages it often happens that evolution takes place without leaving traces of the various stages. This is especially the case in complex organs which have been produced by many lines of evolution converging in a single structure—a structure which thus becomes the seat of a special function or set of functions.

Extrauterine Periods of Stress. During the whole developmental periods of man, extending over the first thirty years of his life, marked

changes in the nervous system and associated organs occur. There is a constant demand on the powers of nutrition. During this period, vegetative life undergoes several marked changes. Thus are produced what may be called the post-natal periods of stress. The first period of infancy is comparatively uniform and extends to the eruption of the temporary teeth, which marks the beginning of the post-natal or second period of stress. During this period of infancy, disturbances are seldom met with, if the infant be properly protected. The food is introduced in a practically sterile condition from the mother's breast. In the absence of infections, the respiratory and circulatory apparatus act normally and growth is uninterrupted after the first normal decrease in weight.

With eruption of the temporary teeth, begins the second period of stress. This event involves a series of changes which occupy the time from six months to two years after birth, and are almost as remarkable as the changes occurring in the early weeks of intrauterine gestation.

During this period, the digestive organs assume more complex functions. Teeth prepare the solid food. The intestinal canal becomes accustomed to the presence of normal micro-organisms and prepared to resist the invasion of injurious germs; urination and defecation become subject to voluntary control and restraints of decency. Power to stand upright and to walk is attained. The faculty of speech is developed. At this period, deformities of the head, face, nose, jaws and teeth are seen.

The second dentition, beginning with the sixth year, forms the third period of stress. Here deformities of the head, face, nose, jaws and teeth are more noticeable.

The fourth is ushered in by puberty at which time the generative organs begin to be functionally active. Marked changes occur in the mind and nervous system at this time. The osseous system reaches its complete development at the close of adolescence and the organism in general assumes a stable condition, which it maintains without apparent change throughout adult life.

The climacteric, occurring in women at about the fifth decade, and the failure of sexual powers in man somewhat later, necessitates re-adjustments of metabolism of great importance to all organs. This may be called the fifth period of stress.

Lastly, there is the period of decadence and senility in which the unity of the organism is indicated, not by the preservation of all in full vigor, but by the economy with which the failing resources are applied to the maintenance of vitally necessary organs to the detriment of those whose functions are less essential. In this period, the teeth are liable to soften and to be lost as a result of interstitial gingivitis and are not replaced; the jaw atrophies and similar changes take place in other parts of the

body. It is difficult to separate, at this period, the essential effects of failing nutritive power from the results of disease. Could he be protected from the inroads of disease, which must materially modify the natural process, man would degenerate and die in a different way from that commonly observed. Premature senility may evince itself in atheroma of the arteries at the periods of extrauterine stress. This has been observed frequently in children of vegetarians, and after fevers.

Owing to the struggle for existence, which occurs at puberty, between the old type of the chondrocranium and its new type as supplemented by the dermal bones, the nervous system may take a distorted ply and arrest bodily, nervous and mental development, so that body and face remain at the childish point; or the body and nervous system are checked; or, finally, the nervous system of certain organs alone are checked, while the body goes on to full development. Not infrequently, the face is arrested at any period from birth to puberty. Hence many persons retain a youthful appearance through life.

Heredity and Atavism. The questions involved in heredity and embryonic development as concerned in mal-development are by no means so simple as the average practitioner assumes. As previously stated, at the outset, all vertebrate embryos assume the same type before definitely differentiating into their final type. Arrests of development, hence, produce conditions found in lower types. Some arrests may be for the benefit of the body as a whole, while others are an arrest of the type. There is a struggle for assimilable nutriment between the different structures of the embryo.

Nature is "careful of the type but careless of the single life." Heredity, therefore, tends most thoroughly to preserve the type, and here heredity is aided by atavism. Throwbacks (atavisms) preserve the most recent type against gains or losses from heredity of parental characteristics. The single life represented by the parent leaves but a slight impress compared with the influences which have made the human type as distinct from the lower types. The single life of the parent may improve or deface the type as represented in him or her, at adolescence or, later, during the period of reproductive activity.

Atavism (or throwback) does not always "drag evolution in the mud," for throwbacks tend to preserve the human type at the expense of the parental gains or losses. Either gain or loss may be attained at the expense of that balance which, through the great law of conservation and correlation of force, constitutes strength. The possible gains of a type foreshadowed in the child are, for this reason, never fully realized in the adult (Fig. 51). The child is not an undeveloped man, but man is an imperfectly developed child. The human infant presents, in an exaggerated form, the chief

distinctive characteristics of humanity—the large head and brain, the small face, the hairlessness, the delicate, bony system. The child has not only these higher characteristics but a better liver, heart and lungs. As

FIGURE 51

The contrast between the prophecy of child development and adult fulfilment (modified from Havelock Ellis). The central figure, the child, shows a relatively large head; large belly; short and fat limbs. The picture to the left shows the man as a grown up child. If the brain should develop in proportion to that of the child, man would become a much greater factor in the world. Figure to the right shows the normal developed man. Brain, liver, lungs, kidneys and body have been sacrificed for the benefit of the limbs.

has been well said, he is all brains, chest and belly. With growth into the adult, these organs not only cease to develop, but are relatively sacrificed to the bony system, a loss probably better adapted to environment, but like the greater loss in the adult apes and lower races, a growth in senility and degeneration. Did environment favor the retention of the high type, foreshadowed just as described in the child, the genius type would be the rule, not the exception.

Through type heredity and atavism, the individual is thus sacrificed for the race. Reproduction is a race characteristic and to it, as Herbert Spencer has shown, higher possibilities of the individual are often sacrificed. Immediate heredity would imply defect if it were not usually more than

compensated for by type heredity and immediate atavism, which reverts to higher ancestral types. In this way, embryonic types, from defective heredity persist after birth. The cyclops, with its primitive face and nose, is an arrest of development at the embryonic time when the pineal body was equal in possibilities as an eye with the bi-lateral eyes. Maternal environment or its reverse may exercise an enormous influence on embryonic development in the direction of arrested or progressive evolution. Maternal shock produces arrests of development which are not photographic impressions, but survivals of embryonic states. While maternal impressions do have an affect, as before stated, it is in conditions of arrest, and not in photographic reproductions of the alleged cause of the impression. Therefore, at periods of stress, some structures disappear and others develop.

The question whether degeneracy or pathologic factors be malign turns on how the structures affected stand toward the complete development of the individual. The structures of the face, as Minot has shown, are, in man, degenerate as viewed from the vertebrate type. They are structures which, quite early in evolution, have been sacrificed to the gains of the central nervous system. On them, therefore, struggles for existence between organs at the periods of stress leave most decided marks.

One of the phases of stress which result from the sacrifice of brain, chest and abdominal organs to limbs and bone is a nutritive one. Nutritive stress occurs very early with the change from placental nutrition to mammary. The child's organs, immediately after birth, work badly and a decrease in weight results. The relative loss in lung states, in liver, kidney and pancreas interfere with proper oxidation as much as does the relative loss of brain bulk interfere with proper inhibitory powers during the periods of stress. Among one of the results of this is premature obesity, a nutritive expression of stress particularly noticeable at the second dentition and at puberty.

According to Féré, puberty lipomatosis (first noticed by Cruveilhier) is an expression of nutritive stress at the periods of evolution. It usually occurs in the descendants of instabilities or in the children of mothers who have been under strain during pregnancy. It is attended by great liability to disease and a marked tendency to systemic weakness when under morbid influence. These children are peculiarly liable to rheumatism, gout, etc., and great hemmorrhages from slight causes. Liver lipomatosis is often associated with precocious maturity and resultant early senescence (senility). Very often it co-exists with protracted infantilism. Ninety-two per cent. of lipomatosic children examined by me had deformed ears to a marked degree. Sixty-six per cent. had arrested development while twelve per cent. presented excessive development.

In eleven cases where the child was too young to determine jaw character, the molars, incisors, cuspids, and bi-cuspid were present. Eighty-seven of the total number examined had arrested development of the upper jaw. Twenty-two per cent. had arrested development of the lower jaw. Sixty-four per cent. had V-shaped or saddle-shaped dental arches or their modifications and protruded teeth. Seventeen per cent. had hypertrophy of the alveolar process. Eighty-three per cent. were microdonts. Twenty-seven per cent. had extra tubercles upon the molars. Eighty-two per cent. had more or less marked stenosis of the nasal cavity. Thirty-six per cent. had deflection of the nasal septum to the left and twenty-nine per cent. to the right. Twenty-one per cent. wore glasses for eye defects. In fifty-eight per cent. the thyroid gland was enlarged and in seven per cent. it was arrested in development, both conditions compatible with hypothyroidism. In two hundred and ninety-six cases of puberty with lipomatosis (one hundred and eighty males and one hundred and sixteen females) reported by Kiernan, there were ten cryptorchids, six hypospadiacs and three cases of pseudo-hermaphroditism. Three females had infantile bifid uteri; four enlarged clitorides; in one of these, the urethra perforated the clitoris as in the female shrew. Of forty girls who had reached the age of eighteen, only three menstruated normally. The others were amenorrhoeic or dysmenorrhoeic (of whom one-half had membraneous dysmenorrhoea) or had neurotic storms during the period. Sexual appetite anomalies were exceedingly frequent. There were one hundred and sixty hebephreniacs, ten cyclothymiacs, thirty acute cases of insanity, ten epileptics, fifteen hysterics and thirteen choreics. Ninety-seven had difficulty in learning to speak and thirty always stuttered. Other general nervous instabilities were present to an equal degree.

Degenerate Children early manifest decided neurotic excitability, and tend to neuroses at physiologic crises like the first and second dentition (second and third periods of stress) and the onset and close of puberty (fourth period of stress). Slight physical or mental pertubation is followed by sleeplessness, delirium, hallucinations, etc., there is hyperesthesia and excessive re-action to pleasant or offensive impressions; vasomotor instability is present; pallor, blushing, palpitations or precordial anxiety result from trivial moral or physical excitants. Precocity or abberation of the sexual instinct often occurs. Psychic pain arises from the most trivial cause and finds expression in emotional outbursts. Sympathies and antipathies are equally intense. The mental life swings between the periods of exaltation and depression, alternating with brief epochs of healthy indifference. Egotism is supreme and morality absent or perverted. The latter condition is often concealed under the guise of moral superiority, religiosity or cant. Vanity and jealous suspiciousness are

common; intellect and temper are exceedingly irregular. Monotonously feeble, scanty ideation passes readily into seeming brilliance, even to the extent of hallucinations, but ideas are barren, as a rule, because generated so rapidly as to destroy each other ere they pass into action. Energy fails ere aught can be completed. The inability to distinguish between desires and facts produces seeming mendacity. The will, in its apparent exuberance, its capricious energy and innate futility, matches and distorts the one-sided talent or whimsical genius which may exist. The whole of this mental state may not be present. The tendency to introspection, to morbid fear, to gloom, to hallucinations, to alternations of depression and exaltation, may occur in a degenerate child in whom has been otherwise preserved that secondary ego, which is the latest and greatest acquirement of the race.

Among signs of fatigue, especially at the second period of stress, is the slight amount of force expended in movement, often with asymmetry of balance in the body. The fatigued centers may be unequally exhausted; spontaneous finger twitches like those of younger children may be seen, and slight movement may be excited by noises. The head is often held on one side; the arms, when extended, are not held horizontally and usually the left is lower. The face is not necessarily evidence of bodily nutrition, as it may be well nourished, yet the body be thin. Three per cent. of the school children are below par in nutrition. They are of low constitutional power. They tend to an ill-nourished condition under the stress of life and, in many cases, to mental excitement which, while rendering them sharper mentally, militates against general nutrition.

School strain produces, like all the acquired factors of degeneracy, a systemic nervous exhaustion which may be expressed either in general neuropathy or hysteria after puberty or in the trophoneuroses, like gout and allied states, or in epilepsy or arterial change, predisposing to rupture of arteries at periods of stress with resultant convulsions and paralysis.

Defects of nutrition, due to an unstable nervous system, either in the parents or child or both, are therefore most demonstrable at the periods of stress.

Having considered the periods in the life of man when the great departures in structure from the normal take place, we will now consider the causes which are instrumental in bringing about these changes.

Summary

The ontogenetic development of man reiterates invertebrate and vertebrate types, and, in the process, structures and organs are lost and modified for the benefit of the whole organism. Writers on the subject

all recognize this law, differing only in their wording of it. Aristotle called it the "law of economy of growth," whereby an organ or structure is lost or modified for the benefit of the organism as a whole; Lucretius showed, long ago, how the strongest survive and the weak are laid low for the "survival of the fittest"; Lamarck spoke of the "use and disuse of structure"; Darwin, harmonizing all of these concepts, called the principle "natural selection," and Osborn, in the study of animals, the "law of compensation."

In man's development from the primitive cell, certain unfavorable influences create a stress or struggle between parts.

A period of stress is a disturbance of physiologic balance. The development of new structures and the loss of others make necessary a systemic re-adjustment through the co-ordinating influence of the central nervous system. In pregnancy, for example, although it is temporary and regarded as physiologic, the system has to re-adjust itself to the new state of affairs, and it is, therefore, a period of stress.

Periods of stress act upon the organism either as a whole or in its parts. Three chief kinds of influence, mechanic, toxic and nutritive, produce irregularities or degenerations in cell or organ development, and these deviations take the form of either arrest or over development of the evolutional types of structure that prevail at the time of stress.

Periods of stress occurring during development are periods of evolution; those occurring after maturity, periods of involution.

Periods of stress are intra and extra uterine. The first intra-uterine period of stress is the early third of embryonic life, when structures are being differentiated, and this is the period when the most marked deformities occur. The embryonic points of stress which call for greatest attention are the time of sex differentiation and the simian (senile) period. Extra-uterine periods of stress are first and second dentition, puberty and adolescence, climacteric and senility. The observable effects of intra-uterine stress are not always seen until long after birth—often they come out under the influence of some extra-uterine stress.

The power to pass unscathed through fetal periods of stress depends upon the condition of the fetus at the time, and this, in turn, depends upon inherited and maternal conditions, especially the latter. Defect in either leads to arrest or over-development of organs or parts which correspond to the stage of development prevailing at the time.

Periods of stress affect most strongly the variable elements of the organism, especially the brain and nervous system, upon whose proper development all of the parts and organs of the body depend for their normal growth and functionation; and it is in this indirect way, through the nervous system, that most body degenerations are brought about.

The questions involved in heredity are thus not nearly so simple as is commonly supposed. The direct influence of heredity, operating through the individual parents, and the wide influence of phylogenetic development, acting through atavism (reversion to type), continually re-act upon each other in the offspring to preserve that wholesome balance which constitutes strength. For this reason the promise of the type, foreshadowed in the infant, is never fully realized in the adult; and in this way the steady, constant progress of phylogenetic evolution is insured. Thus, considered as a whole and from the standpoint of the race, periods of stress and their resulting degeneracies are all factors in the evolutional process. It is only from the individual standpoint and in the more extreme cases that degeneracies call for the interference of the physician.

Chapter IX

AN UNSTABLE NERVOUS SYSTEM THE CAUSE OF NUTRITIVE DISTURBANCES

Checks on Excessive Action not Properly Developed

BEFORE proceeding with the study of an unstable nervous system and checks on proper development, a clear understanding of the law governing arrest and excessive development must be had.

In Chapter II, phylogeny was defined as the development of man from the lowest cell to the species; ontogeny, the development of man from the primitive cell to the grown up individual. Arrests, hence, occur in both phylogeny and ontogeny.

Arrests in Phylogeny are a condition which exists in an organ or structure resembling vertebrate forms, namely fish, reptile, bird and mammal and hence called reversions.

Arrests in Ontogeny are a condition which exists in an organ or structure that has not attained the full development of the human type.

This is excellently illustrated in the following diagram (Fig. 52). Man,

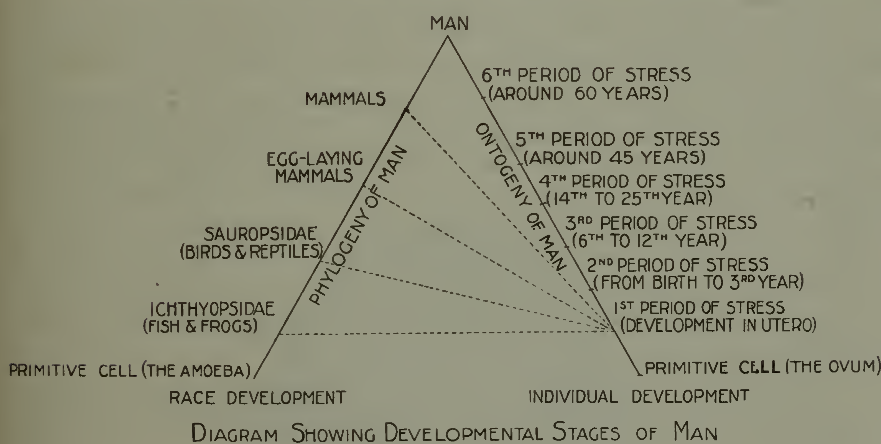


Figure 52

Diagram showing developmental stages of man (original). Man, in his phylogeny (evolution) from the amoeba passes through all the stages of development from fish to reptile and from bird to mammal, arriving at the highest development or human being. In his ontogeny or individual development from the primitive cell passes through different periods of stress. It is at these periods of stress that new structures develop and others disappear under the law of economy of growth. These periods of stress are critical moments in the life of the individual.

at the first period of stress in his development (phylogeny) in utero, passes through the various stages of fish, reptile, bird and mammal.

Owing to an unstable nervous system in the parents, arrests may take place at any one or a number of these types so that when the child is born, his general appearance or a structure or organ may resemble one or more of these vertebrate forms. Again, man in his development from the primitive cell (ontogeny) passes through different periods of stress at which time a new function disturbs the physiologic balance previously existing. At these periods, the organism must adapt itself to the disturbance. Owing to an unstable nervous system in the child, excess or under development may and often does take place at these periods. Race development (phylogeny) shows retrogressive changes, while individual development (ontogeny) shows individual arrests. Occasionally, the disturbance is so great that the child does not survive. Again the child may retain reserve forces or human skill may bridge over these periods and the individual may succumb later, as a result of the new functional disturbance.

The nervous system is composed of two factors, one of which is to give action, the other to check excessive action. An unstable nervous system is one in which the check on excessive action has either not been properly developed or has been weakened.

The important factor regulating bodily nutrition is the nervous system. All parts of the body contain nervous tissues which influence each other by impulses passing over nerve fiber. In the lowest organisms these nervous influences are indeterminate, irregular. They exist in tissues and organisms in which, as at certain phases of fetal life, nerves of definite structure cannot be determined. That nervous influence, or in other words, impulses transmitted from one cell to another, occur in tissues where the histologic structure of nerves cannot be demonstrated, is evident in the fact that the mammalian heart beats automatically before nerves are demonstrable in it, performing acts similar to those which are regulated by nerves.

Inhibition. In higher animals, nervous impulses are inhibited, controlled and originated by the higher nerve centers. The highest functions of the nervous system are centered in the brain. The power of the nerves over nutrition is more strikingly shown in the nerves which control the nutritive supply of the muscles. If the trunk of a motor nerve be cut, the nerve fibers below the severed point, and the muscles supplied by the nerve, degenerate and atrophy. This also occurs if the nerve be compressed, inflamed, or if the ganglion cells in the spinal cord, from which the nerve fibers spring, are destroyed by injury or disease. If the nerve trunk be cut, the degenerated fibers are at length replaced in the process

of healing by new fibers and the muscle recovers its function and nourishment when the regenerated fibers grow out to it. If the nerve be compressed or inflamed a similar process occurs. Regeneration takes place from the central end and nutrition of the atrophied muscles is restored. But if the ganglion cells have been destroyed, the atrophy and loss of functions in the muscle is permanent. To this there is one exception. It is possible by the operation of nerve grafting to bring degenerated nerve and muscle fibers under the influence of nerve fibers still in connection with live ganglion cells, and under the influence of these cells they may be regenerated.

An unstable nervous system in the parents causes nutritive disturbances in the fetus at the first period of intrauterine stress. The brain is one of the fetal structures frequently involved, and, since the brain of the child presides over the child's development, an unstable brain produces nutritive disturbances. Thus, there results a vicious circle which calls for serious consideration. How far a defectively developed hypophysis may influence ossification of tissue in different parts of the body is yet to be determined. There is no doubt that from what little we know about its influence upon other tissue development, it must exert an influence on bone tissue.

When defects in brain structure occur,the different forms of degeneracy, already mentioned in Chapter III, appear. Degenerates possess a greater number, and, as a rule, more marked forms of stigmata than normal individuals. Therefore it is best to consider the nutritive disturbances of the brain of degenerates before discussing the effects of an unstable nervous system upon the development and growth of other structures of the body.

Brain Degeneracy. Of the check on excessive action due to a want

Figure 53
Durencephalous child (original). Marked arrest of development of the brain, cranium and ear. An arrest in phylogeny at the reptilian stage.

of proper development, the most extreme illustration is that of the durencephalous child (Fig. 53), which so often appears in degenerate families. Here the cerebral hemispheres, and in fact everything but the medulla and pons, may be absent. In this illustration is shown the arrest of development of the skull at the prevertebrate period. Here the secondary skull, formed by the dermal bones, which is an advance in evolution, is lacking.

Starting with such an extreme expression of brain degeneracy, a wide but closely linked range of deficiencies may be found in degenerates involving, even in some seemingly normal individuals, more than simple deficiency. What was pointed out by E. C. Spitzka, of New York, thirty years ago, concerning the brain of hereditary lunatics, is equally true of the brains of other degenerate branches of the same tree. The conventional idea, associating idiocy and imbecility with quantitative deficiency of the fore-brain only, is, as Spitzka remarks, a very imperfect one. The researches of numerous observers have shown that qualitative defects (using the term "qualitative" in its wider sense to cover both morphologic and histologic aberrations) are as common, and are more characteristic features of the degenerate brain.

Classification of Brain Defects. These defects occur under the following heads: 1. Atypical asymmetry of the cerebral hemispheres as regards bulk. 2. Atypical asymmetry in the gyral development. 3. Persistence of embryonic features in the gyral arrangement. 4. Defective development of the great interhemispherical commissure. 5. Irregular and defective development of the great ganglia and of the conducting tracts. 6. Anomalies in the development of the minute elements or neurons (as the cells and associating of fibers are now generally called) of the brain. 7. Abnormal arrangements of the cerebral vascular channels.

All these conditions, separately or in varying degree of combination, are occasionally found in the brain of paranoiacs, moral imbeciles, criminals, deaf-mutes, congenital blind, idiots, paupers, harlots, extreme egotists, one-sided geniuses, kleptomaniacs, habitual liars, "smart" business men

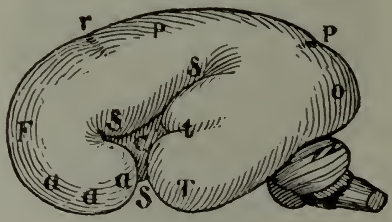


Figure 54

Fetal brain at six months (Bastian). This brain is without convolutions; should arrests take place at this period the child when born would rank below the lemurian type in phylogeny.

and "eccentric" people. These display stigmata to a marked degree. Before considering the different types of defective brains already enumerated, two extremes of normal healthy brains need comparison. Fig. 54 illustrates a fetal brain at six months. No convolutions have yet developed, though the fissure of Sylvius is well marked. The surface of the brain is smooth and, therefore, is below the lemur type of development. Comparing this brain with that of Fig. 55 it will be noticed that, from an atavistic

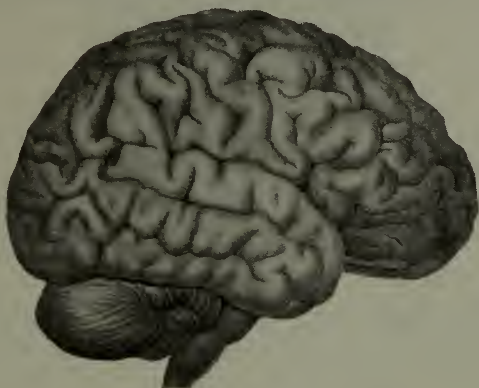


FIGURE 55
Normal healthy brain (Carus's "Soul of Man"). This is a normal healthy brain.

point of view (where no convolutions are present), it represents the vertebrate types below the lemurs in intelligence. The contrast between this fetal brain and that of the ideally normal, highly developed one of the great mathematician, Gauss (Fig. 56), indicates a long step in phylo-

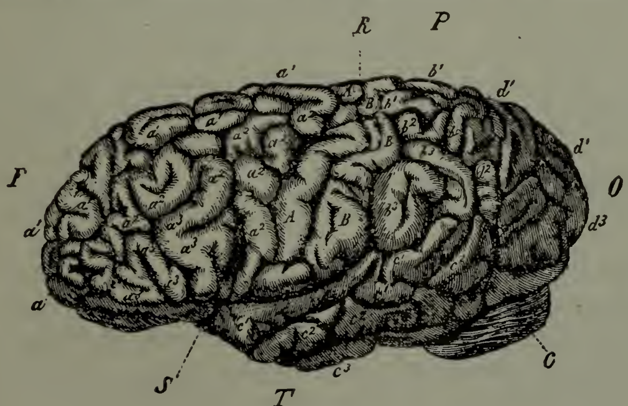


FIGURE 56
Brain of the mathematician Gauss (Vogt). This brain shows a much higher development than the previous illustration. The convolutions are smaller, giving a wider surface to the gray matter.

genetic and ontogenetic development. Deficiencies in brain development, therefore, starting with the six months' fetal brain, may take any one of the various forms before the type development is attained.

TYPES OF BRAIN ARREST. Illustration of different types of brain arrest enumerated by Spitzka is first seen in Fig. 57, which shows asym-

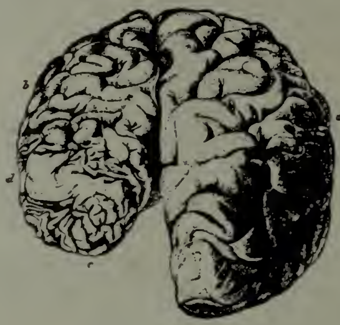


FIGURE 57
Paranoiac criminal brain (Ziegler). The left cerebral hemisphere is markedly arrested in ontogenic development. The convolutions are small to compensate for bulk.

metry of the cerebral hemispheres as regards bulk. This brain, observed by J. G. Kiernan, came from a paranoiac criminal who died in the Chicago (Cook County) Hospital for the Insane.

A very similar brain was also observed by Kiernan in one of the paranoiacs dying in the New York Insane Hospital. Similar brains have been observed in deaf-mutes, whose mental states passed muster because of the allowance made for mental deficiency due to deaf muteness. A brain showing asymmetry was found in a French physician of standing, who was a member of a mutual autopsy society. He proved, however, to have had degenerates in his ancestry and exhibited peculiarities which showed that much degeneracy, due to ancestry, had been corrected by proper training. The defects enumerated under Spitzka's second head are likewise observable in the illustration given. The gyres are not only asymmetrical as to their number in the two hemispheres, but also as to their size.

Fig. 58 well illustrates the third classification, in which the presence of embryonic, as well as atavistic features, in the gyral arrangement, and the brain as a whole, are concerned. This is the brain of an idiot (Fig. 104). The arrest of development took place at the lemurian period and compares favorably with Fig. 20. The anterior and posterior development of the cerebrum is wanting and the gyral arrangement and size are embryonic. Another illustration of the third classification, that of an imbecile (Fig. 59), examined by E. C. Spitzka shows an arrest of fetal development at a higher

phylogenetic period than that of Fig. 58. The anterior and posterior development cover both the cerebellum and the optic lobes which was not the case in Fig. 58. In this illustration, the convolutions, in general, were

FIGURE 58
Brain of an idiot (Ziegler). This brain became arrested in development in its phylogeny at the lemurian stage.

few, large and well marked. The occipital and parietal lobes preponderated in mass, as compared with the temporal and frontal. The latter were greatly hollowed out on the orbital face, and the gyri here found were few, simple and atypical. On the whole, the convolutions of the right hemisphere were better marked and the secondary folds more numerous than those of the left hemisphere, and the type of the convolutions presented

FIGURE 59
Brain of an imbecile (Spitzka). The convolutions are few, large and well marked. The arrest in phylogeny has taken place a little later than the previous illustration.

differences on the two sides. The most pronounced differences were exhibited in the island of Reil and in the occipital lobe. The island of Reil on the left side had fewer and flatter gyri than that of the right side, and resembled in its general aspect the first impression of the brain of an orang-outang. The right island had six folds better marked than those of the left side, but their type was decidedly radiatory, which was in relation with the unusual shortening of the insular field. The external perpendicular occipital sulcus (which Bischoff never found in the adult human brain, but which has been found persistent in a case of imbecility with moral perversion by Sander, and in a sane neurotic individual by Meynert) was finely marked upon the right side of the brain under consideration. The

fissure was very deep; its posterior wall was slightly bevelled and covered several secondary gyri of its anterior walls. It differed in position from the similar fissures described by Meynert and Sander in that it did not, as in their cases, unite with the internal perpendicular occipital sulcus and thus simulate the specialized arrangement found in the anthropoid apes. It was merely the unobliterated external occipital fissure of the embryo, and, as in the latter, its medial end, if prolonged, would have fallen behind the internal perpendicular occipital sulcus. The anomaly consisted, therefore, in the preservation of an embryonic feature.

The fourth classification, defective development of the great inter-hemispherical commissure, is one of great importance. The corpus callosum, which unites the two hemispheres of the brain, is a broad thick mass of fibers which pass transversely across the median plain. These fibers radiate in all directions towards the cortex and intersect the fibers of the corona radiata. Defect, then, in the development of the corpus callosum (which frequently occurs in degenerates) must necessarily affect, to a greater or less extent, the mentality of the individual. It will be seen that mentality is not dependent on the relative proportions of white and gray matter so much as upon the great bundles of fibers, known as the corpus callosum which connect the two sides of the brain.

In the fifth classification, irregular and defective development of the great ganglia and of the conducting tracts involves many strictures. Nay, part of the brain may cease to develop or become diseased, and deficiency in cell area, fibers extending from those cells through the ganglia or the ganglia themselves may be undeveloped.

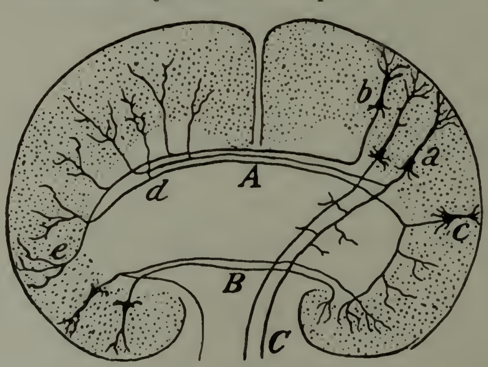


Figure 60

A diagrammatic scheme of the course of the fibers within the brain (Ramon y Cajal). *A*, corpus callosum; *B*, anterior commissure; *C*, pyramidal tract; *a*, neuron with projective fibers and collateral commissural fibers; *b*, neuron with fibers to the corpus callosum; *c*, neuron with associative fibers; *ed*, terminal ramifications of various neurons in the cerebral cortex.

These nerve fibers connect with every tissue of the body. Were it not for the manifold connections of the nerve cells in the outer layers of brain matter with each other as well as with the rest of the body by means of the millions and millions of fibers which make up the white matter such a brain would be as useless as a multitude of telephone or telegraph stations with all interconnecting wires destroyed. Fig. 60 shows some of these fibers extending from the cortical surface through the great ganglia down the spinal cord which connect every structure of the body below the head with the brain.

Cerebral Localization. From the sequelae of injuries, including gun shot wounds, surgeons have been able to outline the different areas of the brain. This has been accomplished by examination of the body when brain lesions have occurred and noting the structures involved. These observations have, from time to time, been recorded, as a result of which a map has been produced, Fig. 61, giving an outline of the brain

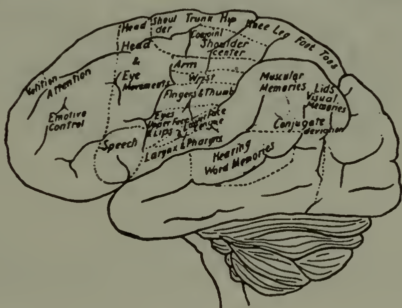


Figure 61

Brain map; specialized function in the cortex cerebri (Dana). From gun shot wounds and other injuries of the brain and their results upon the different tissues of the body, surgeons have been able to map out the areas of the brain affecting nutrition.

areas in direct communication through the nerve fibers with different parts of the body. Areas of the brain which preside over the action of the various structures of the body may be improperly developed, with the same result as disease of the same areas only here the check influence on development is lacking.

If a section of the brain is prepared at any locality mapped out in Fig. 61, nerve cells in different shapes and degree of development will be observed as seen in Fig. 62. These nerve cells and their associating fibers are the structures included in Spitzka's six classifications. These cells or neurons, through their prolongations, establish relations with other neurons, and these are grouped into the larger and smaller nerve trunks which connect the different parts of the brain or extend through the spinal tract to all parts of the body.

In the seventh classification, deficiencies in the cerebral vascular system underlie the pathologic phenomena the basis of infantile cerebral paralysis and allied hereditary and congenital states. The degenerate conditions in the spinal cord are essentially those described by Spitzka as

FIGURE 62
Cortical specialized cells of the brain (Dana). These cells are in different stages of phylogenic development, some with their connecting fibers.

occurring in the brain. Similar vascular states, either as to irregularities in the number of vessels or in the vessels themselves, underlie hereditary ataxias and other congenital and hereditary spinal cord disorders.

INFLUENCE OF NERVES ON NUTRITION. The general nutrition of the body is evidently under the influence of the nervous system. According to DeMoor, the causes which are active in producing degeneration may all be referred to the limited nature of the means of subsistence, that is to say, of nourishment of the body tissues. This limitation causes a struggle between organisms and between their component parts. In the course of the perpetual struggle for existence among the different parts of an individual, the organs which have ceased to be functional tend to disappear, their nourishment being absorbed by the active parts.

The stature is determined in some unknown way by the action of organs closely connected with the brain. The thyroid gland through its peculiar connection with the nervous system exerts an influence shown in goiter, myxedema and Grave's disease (exophthalmic goiter). The influence of the thyroid on growth is shown in the effects of feeding thyroid

gland to cretins (dwarf idiots whose thyroids are undeveloped or degenerated). Such dwarfs usually begin to grow as soon as the thyroid substance is fed to them. We may best explain its action through the nervous system. The limitation of growth is probably due to the action of another gland, the pituitary body or hypophysis, in close connection with the brain. When this organ is diseased, abnormal growth takes place, sometimes in the form of an enlargement of the extremities (acromegaly), sometimes in the growth of the whole body by which the person becomes a giant or is arrested in development. The hypophysis, therefore, regulates growth of the body.

Of the various causes which produce defects in body development, imperfect developed brain areas, want of cell development and connecting nerve fibers with different parts of the body, are underlying factors.

Summary

It is necessary to have a clear understanding of the law upon which arrest and excessive growth is dependent.

Phylogeny is the development of man from the lowest cell to the species. Ontogeny is the development of man from the primitive cell to the fully grown individual type. Arrests occur in both.

Arrests in phylogenetic development resemble fish, reptile, bird and mammal types and are hence atavistic.

Arrests in ontogenetic development exist in organs or structures that have not attained the full human type.

A diagrammatic figure aptly illustrates man's development from the first period of stress through fish, reptile, bird and mammal types of intrauterine life.

An unstable nervous system in the parents cause these arrests in the child to take place at any of the intrauterine periods of stress. In man's ontogenetic development, in passing through the different periods of stress, his physiologic balance may be so disturbed by new functions that he cannot survive. Sometimes the child may be able to overcome these for a time but finally succumbs as result of the disturbance.

The function of the nervous system is to give and check excessive action and to regulate bodily nutrition. An unstable nervous system is one not properly developed or weakened.

Nervous influences in the lower organisms are indeterminate and irregular; in the higher animals, they are dependent upon higher nerve centers.

Unstable nervous systems of parents cause fetal nutritive disturbances oftentimes involving the brain.

Durencephaly is frequent in degeneracy, sometimes only the medulla and pons are present.

Spitzka has shown the relation between the brains of the hereditary insane and other degenerate conditions. The author has taken Spitzka's seven classifications as his guide in the study of brain defect.

The thyroid gland has a peculiar influence on growth, through the nervous system. The pituitary gland also exerts an influence on growth. Disease of this organ results either in dwarfism or giantism.

Chapter X

AN UNSTABLE NERVOUS SYSTEM THE CAUSE OF NUTRITIVE DISTURBANCES

Checks on Excessive Action Weakened

(1). Relaxations of Checks on Excessive Action. These are due in the order of their severity to excesses of all kinds, to toxic agents, contagious and infectious diseases, heredity, consanguinous and neurotic inter-marriage, school strain and neurasthenia from any cause in both parent and child.

(2). Agencies Which Produce Neurasthenia or Fagged-out Nervous Systems. These are divisible into the following groups; those embracing condiments, medicines, foods and beverages; those arising from occupations and excessive indulgence, and those from resultant worries and uncertainties.

Tobacco is the most common causative factor, while alcohol and opium contend for second place both as to use and deleterious effects. Alcohol has been repeatedly charged with being the greatest factor in degeneracy. The influence of alcohol on the individual must first be studied to determine its potency and method of action as a cause of race deterioration. Careful medical researches have shown that alcohol produces a nervous state closely resembling that induced by the contagions and infections, and often accompanied by mental disturbance. The acute nervous state to which the term "alcoholism" was applied by Magnus Huss has all the essential characteristics of the nervous state due to the contagions and infections, that is mental exhaustion. The action of alcohol may be limited to the central nervous system and thus produce hereditary loss of power. It may cause changes or degeneracies in the peripheral nerves, which in the off-spring find expression in spinal cord and brain disorder through extension of the morbid process. But for its deteriorating effects on the ovaries and testicles, alcohol would be a most serious social danger. Through these, however, it tends to prevent the survival of the unfit rather than to develop degeneracy.

Opium seems to be the Charybdis on which the human bark strikes that has escaped from the Scylla of alcohol. Its abuse as a narcotic is much older than is generally suspected even among the English-speaking races. Murrell, over ten years ago, demonstrated that the inhabitants of the Lincolnshire fens had long employed opium as a prophylactic against malaria. The ratio of insanity in these regions proved to be very great. The same conditions obtained in certain malarial regions of New Jersey

and Pennsylvania, where the use of strong infusions of the poppy was common. The statistics of Rush as to opium-caused insanity in Pennsylvania indicate that the percentage of American opium abuse at the beginning of the nineteenth century was marked. The drug differs in two important aspects from alcohol—it is nearer in chemical composition to nerve tissue, and the tendency to its use may be transmitted by the mother directly to the fetus, since it passes through the placenta very often unaltered.

Opium is a more dangerous factor of degeneracy than alcohol, since the opium habitue must be in a continuous state of intoxication to carry on his usual avocation, while abstinence from alcohol is perfectly compatible with proper work on the part of the alcoholist. The opium habit is increased by the propaganda carried on by its habitues, who justify their position by urging the use of opium for any ailment, however trifling. Opium, like alcohol, causes nervous exhaustion similar to, but greater than, that of the contagions and infections. The affinity of opium to nerve tissue; its stimulation of the heart, causing increased blood supply to the brain; from its action on the bowels and the resulting increased work of the liver; all serve to intensify this nervous state. Opium does not interfere with the structure and fecundation of the ovaries and testicles like alcohol, hence the danger of the opium habitue's children surviving. Opium, when smoked, stimulates the reproductive apparatus and thus greatly increases the number of degenerates due to this habit, although the defects due to the inheritance of the habit and their consequences lessen survivals.

With tobacco, as with alcohol and opium, the statistic method generally proves fallacious when applied to degenerative effects. The most careful researches show that the typical effects occur as a rule after long continued use of tobacco, sometimes not until twenty years or more. While many smokers reach old age, many fail to do so because they are smokers. The skin is subject to itching and reddening; the nerves of taste are blunted and patches develop in the throat; loss of appetite, epigastric fulness, pain, vomiting and disturbance of bowel function are common. Menstrual disturbance occurs in women and in female cigar-makers abortion and pluriparity are frequent. The sexual appetite is impaired and sometimes sterility and impotence occur. Disturbed heart action, palpitation, rapid and intermitting pulse, precordial anxiety, weakness, faintness and collapse, with sclerosis of the coronary arteries of the heart and left ventricular hypertrophy occur often. Cigars and cigarettes produce irritation of the nose and mucous membrane, diminished smell, chronic hyperemia of the epiglottis and larynx, and sometimes of the trachea and bronchi, predisposing to tubercular infection. Nicotine amblyopia is common, with

central disturbances of the field of vision and slight color blindness. Often there is disorder of the ear tubes and congestion of the drum with loss of auditory power and consequent noises in the ear. The central nervous system is affected. In high schools non-smokers progress faster than smokers. Child smokers from nine to fifteen years of age exhibit less intelligence and more laziness or other degenerative tendencies. Adults have head pressure, sleeplessness or drowsy stupor, depression, apathy and dizziness. There may also be ataxic symptoms, paretic weakness of bowels and bladder, trembling and spasms. Tobacco insanities, though comparatively rare in smokers, are common in snuffers and still more so in chewers. In the precursory stage, which lasts three months, there are general uneasiness, restlessness, anxiety, sleeplessness and mental depression, often of a religious type. After this occurs precordial anxiety, and finally the psychosis proper, consisting of three stages: 1. Hallucinations of all the senses, suicidal tendencies, depression, attacks of fright, with tendency to violence and insomnia. 2. Exhilaration, slight emotional exaltation, with agreeable hallucination after from two to four weeks' relaxation, again followed by excitement. 3. The intervals between exaltation and depression diminish and the patient becomes irritable, but otherwise not alive to his surroundings. Perception and attention are lessened. The patient may be cured in five or six months if he stop tobacco during the first stage. In a year or so, he may recover during the second stage. After the third stage, he is frequently incurable. As the patient often becomes (especially by the use of the cigarette) an habitue before puberty, the proper development and balance of the sexual and intellectual system is checked. These patients break down mentally and physically between fourteen and twenty-five. The moral delinquencies, other than sexual, are often an especial tendency to forgery and deceit of parents. Frequently, adolescent insanity (hebephrenia) is precipitated by tobacco. The cigarette, if used moderately, may be a sedative, but as used is a stimulant, and is often made of spoiled tobacco, resembling in re-action morphine, and acting on animals in a somewhat similar manner. As tobacco turns the salivary glands into excretory glands, it leads to imperfect digestion of starch and to consequent irregular fermentation in the bowels, thus at once furnishing a culture medium for microbes, from which to form more violent toxins, and likewise creating leucomaines, to damage a nervous system over-stimulated by nicotine. This is one great reason why those who use snuff and chew tobacco become insane more frequently than smokers, albeit these last are not exempt.

Statistics from the female employes of the Spanish, French, Cuban and American tobacco factories, while defective and somewhat vitiated by the co-existence of other conditions producing degeneracy, support

the opinion that the maternal tobacco habit (whether intentional or the result of an atmosphere consequent on occupation) is the cause of frequent miscarriage, of high infantile mortality, of defective children and of infantile convulsions. Tobacco, therefore, in its influence on the paternal and maternal organism, exhausts the nervous system so as to produce an acquired transmissible neurosis.

Tea. Professional tea tasters have long been known to suffer from nervous symptoms. Very early in the practice of their occupation the head-pressure symptoms of neurasthenia appear. Tremor also occurs early. While changes in the optic nerve have not been demonstrated beyond a doubt, still eye disorders have been observed in the pauper tea drinkers of the United States and in the tea tasters of Russia, indicating similar changes to those produced by tobacco and alcohol. The tea-cigarette habit has these effects. Bullard finds that tea has a cumulative effect. In his experience toxic effects are not produced by less than five cups daily. The symptoms manifested are those of nervous excitement resembling hysteria, at times almost amounting to fury; nervous dyspepsia; rapid irregular heart action; heart neuralgia; helmet-like sensation and tenderness along the spine. James Wood, of Brooklyn, found that ten per cent. of those under treatment at the city hospitals exhibited similar symptoms. Of these, sixty-nine per cent. were females, and every symptom ascribed by Bullard to tea was seen by Wood in his cases, who also found that the women manifested irregularities in menstruation of neurasthenic or hysterical type. He found that these symptoms were produced by one-half of the quantity of tea charged with these effects by Bullard. The Lancet several years ago, from an editorial analysis of the effects of tea-tippling, took the position that in no small degree nervous symptoms occurring in children during infancy were due to the practice of the mothers both of the working and society class indulging in the excessive use of tea, the excess being judged by its effects on the individual and not by the amount taken. Convulsions and resultant infantile paralysis were frequently noticed among the children of these tea-tipplers. Observations among the factory population and the workers in the clothing sweat-shops show that tea neurasthenia, presenting all the ordinary symptoms of nervous exhaustion, is especially common. It is evident that tea produces a grave form of neurasthenia readily transmissible to descendants. In addition to its effects directly upon the nervous system, tea tends to check both stomach and bowel digestion, and this increases the self-poisoning which is so prominent a cause, consequence and aggravation of these nervous conditions.

Coffee exerts an action very similar to that of tea, although the nervous symptoms produced by it are usually secondary to the disturbances

of the stomach and bowel digestion. Coffee produces tremor, especially of the hands, insomnia, nervous dyspepsia and helmet sensations. With the exception of certain districts of the United States coffee abuse is not carried to such an extent as tea, albeit in these, as in some portions of Germany, the habit is an excessive one. The conditions described result in Germany as frequently as they do in the United States. Mendel finds that in Germany coffee inebriety is increasing and supplanting alcohol. Profound depression with sleeplessness and frequent cortex headaches are early symptoms. Strong coffee will remove these temporarily, but it soon loses its effect and they recur. The heart's action is rapid and irregular and nervous dyspepsia is frequent. L. Bremer, of St. Louis, has observed similar conditions among both Germans and Americans there.

Coca. While coca took its place but recently among the toxic causes of modern degeneracy, it was a factor of Peruvian degeneration long ere the discovery of America. Forty-three years ago, Europeans or people of European origin in different parts of Peru had fallen into the coca abuse. A confirmed chewer of coca, called a coquero, becomes more thoroughly a slave to the leaf than the inveterate drunkard is to alcohol. Sometimes, the coquero is overtaken by an irresistible craving and betakes himself for days together to the woods and there indulges unrestrainedly in coca. Young men of the best families of Peru are considered incurable when addicted to this extreme degree, and they abandon white society and live in the woods or in Indian villages. In Peru the term "white coquero" is used in the same sense as irreclaimable drunkard. The inveterate coquero has an unsteady gait, yellow skin, quivering lips, hesitant speech and general apathy. The drug has assumed prominence in the field of degeneracy, since the discovery of its alkaloid, cocaine. In both Europe and the English-speaking countries, the world over a habit has resulted which, while much over-estimated, is undoubtedly growing and aggravating as well as producing degeneracy. Many of the cases reported as due to cocaine are, however, chargeable to the craving of the hysteric or neurasthenic to secure a new sensation or the desire on the part of the opium or whiskey fiend to try a dodge for forgiveness by friends. The habit is very frequently induced by patent medicines taken to cure catarrh by the neurasthenic or to cure nervousness by hysterics as well. As deformities of the nose passages predispose to "catarrh," patent medicines for local application containing cocaine are frequently employed in the treatment of this supposed constitutional disease, with the result of aggravating the original degeneracy. The youth under stress of puberty frequently ascribes all his ills to catarrh and for it often employs snuffs containing cocaine, and his nervous condition is much aggravated thereby. Among the nostrums urged in the newspapers and magazines for this condition

so often resultant on nerve stress alone is a snuff containing three per cent. of cocaine. From the description given by Johnson of the coquero there can be no doubt that tramps, errabund lunatics and paupers result from this habit to give birth to degenerates in the next generation.

Lead produces in those exposed to its fumes a systemic nervous exhaustion, characterized by local paralysis about the wrist, as well as the general symptoms of profound systemic nerve tire. This may result, as was pointed out nearly half a century ago in acute insanity of the confusional type followed very often by mental disorder of a chronic type resembling paretic dementia. In some cases, the patient recovers from the acute insanity to suffer thereafter from epilepsy. In other cases, an irritable suspicional condition also results, in which the patient may live for years, marry and leave offspring. This last condition and the epileptic are the most dangerous as to the production of degeneracy. The women employed in the pottery factories in Germany suffer, according to Rennert, from a form of lead poisoning which produces decidedly degenerative effects upon the offspring. These women have frequent abortions, often produce deaf-mutes and very frequently macrocephalic children.

Brass workers suffer from a nervous condition very similar to that produced by lead. Hogden, of Birmingham, and Moyer, of Chicago, have called attention to the grave forms of nervous exhaustion produced among brass workers. The period during which the patient is able to pursue the occupation without breaking down is longer than that of lead workers. Women, like men, are exposed to this condition. The chief effects produced, so far as the offspring have been observed, are frequent abortions and infantile paralysis.

Mercury. The occupations involving exposure to mercury, whether mining, mirror-making or gilding, produce forms of systemic nervous exhaustion in which the most marked symptom (but less important from a sanitary standpoint) is a tremor amounting at times almost to the shaking palsy. Like all other systemic nervous exhaustions, the mercurial one may appear as degeneracy in the offspring. The employment of women in match factories and tenement-house sweat-shops is growing. The chief toxic effect of phosphorus is not the localized jaw necrosis. This is but an evidence of the progressive saturation of the system with phosphorus, and bears the same relation to the more dangerous effects of phosphorus that "blue gum" does to the systemic effects of lead.

Every condition of toxic origin capable of producing profound systemic nervous exhaustion in the ancestor, and especially in the ancestress, may produce degeneracy in the descendant. With the growing tendency of woman to pass from the ill-paid work of the seamstress to the better paid but dangerous occupations, a certain seeming increase in degeneracy must result.

Toxins. The influence of contagious and infectious diseases upon developmental pathology or suppressive evolution is by no means slight. Any disease that produces grave constitutional defects in the parent is likely to be intensified in the offspring. The greatest social dangers result from tuberculosis; the next from syphilis. Typhoid fever, scarlatina, small-pox, measles, diphtheria, whooping-cough, and all contagions, however, may produce these constitutional defects, either through the pregnant mother or through their secondary effects on the ancestor's constitution. If the subject be attacked before the close of the periods of dental stress, an arrest of development of the bones of the face may result, with irregularities in the shape and the position of the teeth. These then are stigmata of degeneracy especially due, in the individual presenting them, to the contagions and infections rather than to inheritance alone.

Two agencies producing profound constitutional alteration in a victim, which predispose to degenerative factors like alcohol and which increase the effect of these are, as Kiernan pointed out nearly a quarter of a century ago, traumatism and isolation. There is a deep-seated neurosis produced by these, attended by a suspicional state, and accompanied by metabolic changes which result in glycosuria, and which aggravate the co-existent neuroses. The influence of these states on the offspring I have elsewhere pointed out in their relation to the effect of alcohol.

The relations of heredity are far more intricate than is usually assumed to be the case in the average discussion of the subject. The problem consequent on impregnation involves more than the mere carrying of the mixture of parents in a fully developed form through intrauterine life. Impregnation, moreover, itself depends on the preparation of the ovum for the spermatozoon. The centrosome (a body belonging to the period when the ovum has passed from the parthenogenetic to the primitive hermaphroditic stage) has to disappear ere its quasi-function is assumed by the spermatozoon. Futhermore when the germinal streak has occurred this must be preserved from duplication tending to make duplications of cells or organisms or other minor manifestations of the conditions resultant in double monsters.

As all vertebrate organs pass through the same stages before definitely differentiating, the later types have to gain at the expense of the earlier and hence must receive greater impetus from the direct ancestors. The want of this impetus is shown in the various defects and departures from type which occur in the different degeneracies and congenital defects. For this reason, the descendants of a victim of morbidity or abnormality do not always exhibit the disorders, or not to the same degree. Sometimes the superior strength of the maternal ancestor and her consequent power of nourishment carry the fetus through the period of defect shown by the

father and consequently correct that defect. The types of heredity ordinarily considered are direct heredity where the individual takes after the immediate ancestry, and type heredity where he takes after the type to which he belongs. Concerned in this latter is atavism or reversional heredity, where the individual throws back to immediate remote ancestors. This element of atavism tends, by preserving the type, to offset the defects of immediate heredity and, indeed, often underlies the apparent differences between children of the same parents. It likewise prevents equal inheritance from both parents and sometimes favors inheritance of strength or defect from either. It underlies also so-called collateral or indirect heredity and the transmutation of heredity. While acquired defects and benefits may be, as even Weismann admits, inherited this can occur but rarely, since it not only implies weakness of atavism or type heredity, but likewise weakness of maternal constitution and environment during pregnancy and lactation. Much of the alleged inheritance of paternal defects is due to the environment of the mother produced by this defect, as I have elsewhere pointed out in the discussion of the influence of paternal alcoholism. What is true of alcoholism is, of course, true of all other degenerative factors. The neurasthenic influence of these on the maternal organism during pregnancy and lactation would through simple arrest of maternal function create defective offspring even were there no direct inheritance of defect.

Morbid Heredity. Manifestations of morbid heredity may not be inheritance of the whole effect but disturbance of relations of structure and hence of function, producing a constitutional deficiency which takes the line of least resistance. The extent and direction of this line of least resistance depends upon the amount of healthy atavism which separate organs and structures of the body preserve. What is true of the organism as a whole is true of the cells forming its organs. While cell life is altruistic or subordinated to the life of the organ and through it to the life of the organism as a whole, still this altruism is not so complete as to entirely prevent a struggle for existence on the part of the cells or the individual organs. With advance in evolution, this struggle decreases to increase with the opposite procedure of degeneracy. Its action sometimes aids, and sometimes, when regular, prevents degeneracy. The vertebrate embryo of the higher type has in it all the potentialities for the organs and structures found in lower types. As ancestry is strengthened, these potentialities remain latent. In proportion as the ancestry becomes subject to nervous exhaustion these potentialities gain nutrition at the expense of the later acquired organs which are the ones likely to be affected by nervous exhaustion. Struggles for existence produce effects which are handed down by heredity or are fought by atavism. These two factors in heredity may play beneficial

as well as injurious parts on the offspring. As a rule, atavism plays a beneficial part in correcting degenerate tendencies. This part may either be complete in the shape of a perfect return to a normal ancestor or may be sufficient to moderate in the offspring the effect of an extended exhaustion of an immediate ancestor.

Heredity is a prophecy of what may be, not a destiny which must be. Much is ascribed to heredity that is due to fetal periods of stress and maternal environment during ovulation and pregnancy. To the influence of such environment, is due the failure of the body plasm to reproduce acquired qualities. The germ plasm may, however, be affected by experiments suited to the fetal environment and periods of stress. Thus, also, are produced reversional tendencies through which the body plasm regains reproductive powers lost for the benefit of the whole organism.

This principle is illustrated in the experiments of Dupuy. Here, while as a rule, the scions of guinea-pigs (rendered epileptic by section of the sciatic nerve) were epileptics and had deficient toes, still in some of them epilepsy resulted without the toe anomaly, and still more rarely the toe anomaly was present without the epilepsy.

The same principle is shown by Charrin and Gley, who for five years conducted experiments calculated to throw light on the influence on the offspring of parental reception of virus. Either both male and female have been inoculated with the bacillus of blue pus or its toxins, or but one animal has been inoculated. The results have not been uniform. Most frequently there ensues sterility, abortion, or birth of progeny that die immediately. In rare instances, the offspring survive; more rarely still are they healthy. Certain rabbits (born of these undeveloped animals) were provided with enormous epiphyses (end of bones), the shafts of the bones being shortened. Two rabbits were born of a couple of whom the male alone received inoculations of sterilized culture. Five rabbits were born of these two, of which two were normal and a third (whose ears were rudimentary) died in a few days. In the remaining two the ears comprised only fragments with jagged upper edges. The tails were but two centimeters long. The external orifice of the vagina (one rabbit was a male and the other a female) was oblique. One of the limbs (the hind in the male and the fore in the female) was much shorter than its fellow, showing a difference of four centimeters. The shortened limb ended in a kind of stump, there being no foot or toes.

As Dareste has shown (and the fact has been corroborated by Spitzka), embryologists can imitate natural malformation of the nerve centers by artificial methods. By wounding the embryonic and vascular areas of the chick's germ with a cataract needle, malformations are induced, varying in intensity and character with the earliness of the injury and its precise

extent. More delicate injuries produce less monstrous development. Partial varnishing or irregular heating of the eggshell, in particular, results in anomalies comparable to microcephaly (little head) and cerebral asymmetry. This latter fact (showing the constancy of the injurious effect of so apparently slight an impression as the partial varnishing of a structure not connected with the embryo at all directly) suggests the line of research to be followed in determining the source of the maternal and other impressions acting on the germ. What delicate problems are to be solved in this connection may be inferred from the fact that eggs subjected to the vibration and shocks of a railroad journey are checked in development for several days, or permanently arrested. A more delicate molecular shock during the maturation of the ovum, during its fertilization, or finally during embryonic stages of the more complex and therefore more readily disturbed and distorted human germ accounts for the disastrous effect of insanity, emotion, or other mental or physical shock of the parent on the offspring. The cause of the majority of cerebral deformities exists in the germ prior to the appearance of the separate organs of the body. Artificial deformities produce analogous results because they imitate original germ defects, either by mechanical removal or by some other interference with a special part of the germ. Early involvement of the germ is shown by the fact that the somatic malformations of the hereditary forms of insanity often involve the body elsewhere than in the nervous axis. The stigmata of heredity—defective development of the uro-genital system, deformities of the face and skull, irregular development of the teeth, mis-shapen ears and limbs—owe their grave significance to this fact. Like deformities of the brain, these anomalies are also more marked and constant with the lower forms of the hereditarily based systematised perversions of the mind than the higher. It is easy from these results to understand how far and how deeply the nervous system has its part in the disorders of general development. It can be easily understood how the individuals who present most deformities are equally those who suffer from most decided disorders of the nervous system.

In experimental teratology, the latest examples are the production of cyclopian monsters. Stockard by treating eggs of the common minnow (Fundulus) with solutions of magnesium chlorid immediately after fertilization has produced at will fifty per cent. of cyclopian monsters of various degrees of abnormality. Warren H. Lewis in a parallel series of experiments produced almost identical defects in this fish by destroying in later developmental stages the extreme anterior end of the medullary plate before it has invaginated to form the central nervous system.

Consanguinous and Neurotic Marriages are fruitful sources of degenerate children. Accentuation of family characteristics must always

happen from consanguinous marriages, for if there be taint in the family each member will have inherited more or less of it from the common ancestor.

Cousins, who are descendants of a common grandparent who was insane and of an insane stock inherit more or less of the insane diathesis. Even if the taint has been largely diluted in their case by the wise or fortunate marriages of blood-related parents, they have still inherited a neurotic tendency. If they marry they must not be surprised if that taint appears in aggravated form in their children. Children of such parents may be idiotic, epileptic, dumb, or lymphatic and the parents marvel whence came the imperfection. In some cases, the parents and possibly the grandparents of the unfortunate children have not displayed any obvious evidence of the tendency to disease which they have inherited and handed on to their descendants. Not looking farther back, the parents boldly assert that such a thing as insanity, epilipsy, scrofula, etc., is unknown in their family. They themselves have never been insane, why should their children be? In like manner, children may be epileptic, blind, deaf-mute, lymphatic, cancerous, criminal, drunkards or deformed from direct inheritance and yet the family line be honestly declared healthy. The truth of Sir William Aitken's maxim that "a family history including less than three generations is useless and may even be misleading" is hence obvious.

Similarity of temperament induced by a common environment, which Strahan calls "social consanguinity" is also a potent factor in degeneration. Living under similar customs, habits and surroundings, laboring at the same occupations, and indulging in the same dissipation, tend to engender like diseases and degenerations irrespective of blood relationship. Persons not even distantly related by blood are in reality much more nearly related in temperament than cousins or even nearer blood relations who have experienced widely different modes of life. The "social consanguinity" is the great curse which dogs every exclusive tribe and class and hurries them to extinction. It has largely added to real or family consanguinity in the production of the disease and degeneration which have fallen so heavily upon the aristocracies and royal families of Europe. This "social consanguinity" appears likewise in the tendency of the neurotic to intermarry, popularly expressed in the proverb that "like clings to like." This marital likeness in mental characteristics has been shown to be present by Roller, de Monteyel, Kiernan, Bannister and Manning representing Germany, France, the United States and Australia.

School Strain evinces itself in a systemic nervous exhaustion manifested along lines of least resistance. The first type of neuroses are due to overstrain of certain territories related with memory as constrasted with

diminished use of the association fibers connecting these. In degenerate children, because of deficiencies of proper interassociation of the memory territories in the brain, healthy curiosity and the instinct of sheltering are deficient, so that states of uncertainty, producing terror, result. These become permanent in after life, even when training as adults is strongly antagonistic to them. Over-pressure in school in certain respects checks, even in well-developed minds, the transition from the terror of the unknown of childhood into the calm of maturity. Morbid fears, imperative conceptions, and imperative acts which torture the individual during an otherwise healthy career unquestionably originate in the early periods of life.

Neurasthenia is a common neurosis by which Preston remarks males are equally affected with females. It is nerve instability in which, in addition to ordinary nerve fatigue, there is a morbid susceptibility to emotions and inability to restrain their manifestations. It is apt to make its onset near puberty, when permanent teeth are most liable to decay. Temporary teeth are frequently badly decayed as a result of child neuropathy and hysteria. Permanent teeth later in life decay from premature senile neuropathy. Neurotic inheritance, aided by the influence of climate and race tendencies, and an unstable, badly organized or imperfectly developed nervous system, are potent factors in tooth decay. When to this are added diatheses like tuberculosis, syphilis, etc., causes for tooth decay are enormously increased. Any long-continued disease, grief, fear of litigation or death, also cause nerve fatigue, an excessive nerve waste and its retention. Anxiety, especially of young children, and between the ages of twelve and twenty-four, relative to their standing in school, is a fruitful source of nerve tire, nerve waste and faulty metabolism. The forcing system of schools adds neurasthenia to the list of accomplishments. While "all work and no play makes Jack a dull boy" from nerve tire and self poisoning, the same is even more true of Jack's sister. Few universities do not have in their faculties fairly typical neurasthenics from pedagogic worry and too one-sided life.

The causes just enumerated are in adults fruitful sources of nerve exhaustion. Elsewhere I have frequently shown that any excess is a fecund cause of nerve exhaustion. Neurasthenia occurs in every walk of life. People raised in luxury and idleness are the most evident victims of neurasthenia. Neurasthenia was particularly frequent among the second generations of Puritans, whence the Salem witchcraft epidemic and the miraculous cures related by John Eliot. The lowest classes, who give free rein to the appetites, and the tramps are often neurasthenics, as are those between these two, persons who lead a sedentary life to which is added severe mental strain, care, responsibility, monotony, anxiety.

Neurasthenia is frequent among clerks, teachers, literary workers, etc. It is often the ancestral phase of degeneracy; through it occurs the rapid decay of the teeth in persons over thirty or forty years of age who have had very little decay previously.

Nothing does so much to bring about degeneracy as the exhausting social functions undergone by young women just before marriage. Brides become so exhausted that they can hardly stand at the altar. Women in nourishing their children can not only overcome their own defects but likewise those of their husbands. It is, therefore, better for a prospective bride to isolate herself and rest rather than undergo the stress of social functions in celebration of her approaching marriage. Few women under existing methods of life can rear a family destitute of mental and physical defect. The same was equally true of past centuries, whence the congenitally defective ancestors of the present generation.

Neurasthenia in the parents from all conditions herein enumerated affects pathologically the development of the child. This implies a practical degeneration in function, since tone is lost.

Every nerve cell has two functions, one connected with sensation or motion and the other with growth. If the cell be tired by excessive work along the line of sensation or motion the function as regards growth becomes later impaired, and it not only ceases to continue in strength but becomes self-poisoned. Each of the organs (heart, liver, kidneys, etc.) has its own system of nerves (the sympathetic ganglia) which, while under the control of the spinal cord and brain, acts independently. If these nerves become tired the organ fails to perform its function, the general system becomes both poisoned and ill-fed and nervous exhaustion results. In most cases, however, the brain and spinal cord are first exhausted. The nerves of the organ are then allowed too free play and exhaust themselves later. This systemic exhaustion has local expression in the testicles in the male, in the uterus and ovaries in the female. Because of this condition the body is imperfectly supplied with the natural antitoxins formed by the structures; the general nervous exhaustion becomes more complete and all the organs of the body are weakened in their functions. Practically the neurasthenic in regard to his organs has taken on a degenerative function, although not degenerating in structure, since the restlessness of the organs is a return to the undue expenditure of force which occurs in the lower animals in proportion as it is unchecked by a central nervous system. Through the influence of various exhausting agencies, the spinal cord and brain lose the gains of evolution and the neurasthenic is no longer adjusted to environment. Since the reproductive organs suffer particularly, children born after the acquirement of nervous exhaustion, more or less checked in development as the influence of atavism is healthy or not, repeat degen-

erations in the structure of their organs, which in the parent were represented by neurasthenic disorders in function. As the ovaries of neurasthenic women generally exhibit prominently the effects of the nervous exhaustion, the disappearance of the centrosome is not properly affected and sufficient stimulus by the spermatozoon is not secured and the offspring of these do not gain vigor to pass through the normal process of development.

Summary

The normal checks on excessive functionation and development are subject to two classes of demoralizing influences: (1) relaxations of all kinds and (2) various disease-producing agencies.

In the first class are included excesses, toxic agents, contagions and infections, heredity, consanguinous and neurotic marriages, school strain, and neurasthenia in parent and child.

In the second class are various drugs, improper food, drink, certain occupations, worry, etc.

Tobacco, alcohol and opium vie with each other in their ill effects upon the human economy. Tea, used in excessive quantities, has similar effects to tobacco and alcohol. Coffee induces stomach and bowel disturbances which ultimately affect the nervous system, heart, etc. The chewing of the coca leaf and, in civilized countries, the use of its alkaloid, cocaine, have produced many degenerates. Lead, brass and mercury cause profound nerve tire, appearing as degeneracy in the offspring.

The contagious and infectious diseases produce grave constitutional defects which cannot be overestimated. The great crusade now being waged against tuberculosis may help to minimize this danger. And finally, traumatism and isolation are factors in the increase of degenerative conditions.

The underlying principle by which all of these influences produce degeneracy is that they disturb the physiologic balance between the local nervous system of the various cell-groups and organs and the central co-ordinating nervous system, thus creating among the former a struggle for existence, excessive nerve action, and ultimately exhaustion.

The effect of these disturbances as exercised through heredity involves exceedingly complex processes and phenomena. Fundamentally, they may all be reduced to a lack of the necessary ancestral impetus required to carry the organism through the various stages of its development, with their successive periods of stress. Such hereditary defects are sometimes overcome by the superior strength of the maternal parent, and, as previously explained, atavism (reversion to ancestral types) continually modifies

direct heredity. The phases of heredity commonly observed and considered are those of direct parental influence only. But, as Sir William Aitken has said, "a family history including less than three generations is useless and may even be misleading."

Heredity, therefore, is not a fixed inevitable destiny of what must occur, but a sum of possibilities of what may occur, and these possibilities are affected by the check-disturbing influences which are here considered. Many degeneracies are attributed to heredity which are in reality brought about by intrauterine periods of stress and the environment of the mother during gestation. On the other hand, physical, mental and moral degeneracies may be inherited from a remote ancestor, their effects having remained latent in intervening generations by virtue of compensating influences.

Consanguinous marriages disturb the physiologic balance because of the accentuation of parental qualities, which ought to be balanced by dissimilar qualities. School strain, by its undue concentration of nervous control in certain directions, deprives other important structures and functions of their necessary normal check, and thus leads to physical and mental degeneracies.

To sum it all up, one of the essential phases of upward development in an organism, as in a social body, consists in the greater and greater subordination of local nerve centers to the central co-ordinating system; and any influence which disturbs this co-ordinating process, to the extent of causing excessive local action at the expense of the whole, to that extent puts the organism back into the condition of a lower type of development and constitutes a degeneracy. Normally, the higher potentialities gain at the expense of the lower ones; but when normal check action is disturbed, the lower gain at the expense of the higher, hence the later acquired organs and functions are most likely to be affected by such degeneracies.

Chapter XI

NERVOUS EFFECTS OF RELAXED CHECK ACTION

The influence of the maternal nerves on the development of the fetus is a fact of clinical experience, although the manner in which it is exerted has not been made clear. Whatever may be the truth regarding maternal impressions, there is decided reason to believe that anxiety, neurasthenia, nervous diseases and autointoxication of the mother affect the growth of the fetus.

Maternal Influence Upon Nutrition. Some recent investigations in metabolism afford a possible explanation in the influence of the nervous system of the mother on the nutrition of the fetus. It has been shown that in the case of certain seeds, the nourishment stored up in the albumen of the seed is of a specific nature peculiar to that species. This indicates that the embryo, in building its tissues, must use material derived from an organism of the same species. It is probable that the cells, in developing, build up their protein constituents from comparatively simple amino acids that are peculiar to the species to which the cells belong. It may be possible that each tissue and organ needs for its development its peculiar protein, made up of amino acids different from those found in other parts of the body. This points to the probability that the materials for the growing fetus must be furnished by the breaking down of the maternal tissues. That such a breaking down of the maternal tissues takes place in pregnancy is shown by recent experiments. Such a decomposition, without doubt, takes place under the influence and regulation of the nervous system. If this be the case, it is easy to see how derangement of the nervous system by disease or by unfavorable psychic influences may alter the composition of the material supplied to the fetus and so affect the development of the fetus in general and perhaps also that of particular organs. Sickness and even death of the child has been known to occur by the agency of poisons produced in the breast milk through the agency of powerful emotion in the mother. If such a mishap may occur to the growing child, it is easy to understand that a like occurrence might happen to the fetus from the action of poisons generated by the nervous system of the mother and conveyed to the embryo or fetus by the blood. A direct nervous connection between mother and fetus does not exist. How much influence may be conveyed by the tissues not having nervous structure is not known and although such influence is possible, it is undoubtedly slight and quite indefinite.

Influence of Fetal Nervous System. Little is known of the nervous system of the fetus on its own development, but arguing from the analogy of what happens in extrauterine life, we conceive it to be great. Some nervous diseases are congenital and must have begun in intrauterine life and the infant at birth often exhibits the results of intrauterine nervous disease, particularly of a syphilitic nature. It is, therefore, not reasonable to attribute much of the developmental defects observed at birth to perverted action of the nervous system of the fetus.

Fetal Nervous Diseases. The diseases of the nervous system of the fetus are due either to germs, as those of tuberculosis or syphilis, introduced from the paternal organism with the semen, or to similar germs or poisons introduced by the maternal blood. Poisons may be foreign to the system of the mother reaching her through the food or they may be the result of putrefaction in the intestines, intestinal autointoxication or may arise from the metabolism of her own tissues. As most derangements of the maternal nervous system are the results of autointoxication, it is easily understood how such influences may effect the nervous system of the fetus and hinder the development or cause degeneration of various parts of the body.

After birth, many instances of disturbances of nutrition occur which have their origin in altered nervous function.

Classification of Nervous Diseases. The diseases of the nervous system may be ranged in three classes so far as their etiology and pathology is concerned.

(a) Organic diseases in which the function of a part of the nervous system is more or less permanently suspended because of organic changes in the nerve itself or in the surrounding tissue. These changes are sometimes of an inflammatory nature like myelitis, neuritis, meningitis, etc. At other times, the change is pure degeneration of the nervous substance with little or no inflammatory reaction. The inflammatory changes are brought about by infectious agents, the degenerative by poisons of a non-infectious character. In either case, the function of the nerve or ganglion cell is suspended for a longer or shorter time with a corresponding effect on the nutrition of the parts supplied by the corresponding nerve fiber. If the nerve trunk be affected, degeneration of the muscle occurs, followed, in some cases, by a slow regeneration when the poison has been eliminated. Such is the result of the neuritis that ensues after the ingestion of alcohol, arsenic or allied poisons. A good example is seen in the head palsy, where the nerves supplying the extensor muscles of the forearm are degenerated and the muscles become paralyzed and waste away, giving the phenomena of wrist drop. A similar phenomenon is seen when a nerve is compressed as by the pressure of one bone on the other. A familiar example is seen

in Potts' disease of the spine. The nerves compressed between the distorted vertebrae degenerate and the muscles atrophy. If, however, the pressure is relieved, a regeneration occurs and the muscles are restored to their former state of nutrition and functional activity. If sensory nerves are affected, the skin suffers and bedsores, ulcers, etc., occur. A good example of this influence of the nerve on nutrition is seen in the perforating ulcer of the foot which frequently occurs in locomotor ataxia, a disease in which the essential lesion is a degeneration of the sensory ganglion cells of the spinal nerves and the tracts of the cord connected with them. In cases in which the ganglion cell is affected the paralysis and atrophy of the muscle are permanent.

(b) A second etiology of nervous disease is the action of poisons which produce no recognizable organic change. Such diseases may vary largely in their manifestations at different times. Epilepsy, urticaria, angioneurotic edema, asthma, and a number of neuroses of various organs are of this character. Their influence on nutrition is not so clearly traced as in the former case.

(c) A third class of nervous diseases owe their origin to psychic causes or are accompanied by marked changes in the mental state. These states are mainly grief, worry, nervous breakdown, hysteria, neurasthenia, psychasthenia and the psychoses. Their influence on general nutrition is sometimes very marked.

Thus, emotion has been known to change the color of the hair, initiate serious disturbances in metabolism, affect the teeth so that they decayed very rapidly and produce marked changes in nutrition.

Infectious diseases even when they do not especially affect the nervous system provoke marked disturbance of nutrition. The growth is checked and development is very unfavorably influenced. The hair falls out after many fevers and white areas in the skin and nails are noticed in many instances. Similar changes occur in the teeth.

The sensory nerves have some control over the nutrition of the skin and its appendages through their vasomotor influence. Nervous influences may cause marked changes in the parts supplied by the sensory nerves. Various skin diseases are simply expressions of action on the nerves. Herpes follows the course of a nerve and evidently depends on some cause affecting the nervous system. This may be a toxin such as that of pneumonia which is frequently accompanied by herpes of the lip or it may be a disease causing primary pathologic changes in the nerve itself such as neuritis, meningitis, etc. The erythemata are other manifestations of perverted nervous action. Other dermatoneuroses occur; even eczema is often due to neurotic action.

Vasomotor Control. All the internal organs are supplied by the

sympathetic nerves which control the actions of the viscera and regulate the blood supply of the entire body through the vasomotor nerves which accompany the arteries and regulate the caliber of the smallest blood vessels. So great may be the influence of this nerve on nutrition that gangrene may occur under the influence of certain poisons that act especially on it. Unknown poisons may disturb its action so as to produce similar results. This is the case in Reynaud's disease, in which a spasm of the smaller blood vessels is brought on by some toxin, the nutrition of the parts affected is suspended, and gangrene occurs. Asthma, angioneurotic edema and edema of the lungs are other examples of pathologic conditions that may be brought about by abnormal action of the sympathetic nerve.

Obesity and Leanness. Evidences of the effect of the nervous system on general nutrition are further seen in the disposition to obesity or to emaciation. It is generally noticed that obesity and leanness are characteristics of certain families. Differences of disposition also accompany the two states. The lean people are usually active in intellect, inclined to worry and anxiety; the corpulent are usually easy going, often slow of action and sometimes dull in intellect. The two conditions are to be regarded rather as the effects of the action of the differently constituted nervous system for we often see the emaciating effects of an excited or diseased brain.

Special changes in metabolism are also occasioned by the action of the nerves. Certain cases of diabetes and albuminuria are due to the growth of tumors in the fourth ventricle. Glycosuria can be produced by a puncture of a certain part of the floor of the fourth ventricle. Diabetes can often be traced to the influence of grief, anxiety, etc., which without doubt, act through the nervous system.

Summary

Just how maternal impressions affect the unborn child has not been intelligently explained. It is a well known fact, however, that grief, worry, disease and environment of the mother affect the development of the child. It is probable that the proper breaking up of the maternal elements of nutrition depends upon normal nervous control, and disturbance of this control results in vitiated fetal nutrition.

Severe illness and even death of the nursing child have been known to occur through the emotions of the mother, and the same condition in utero could occur through the action of the blood, since there is no direct nerve relation between mother and unborn child.

To judge from the influence of the nervous system upon development after birth, a great influence must be exercised on the development of the

fetus by its own nervous system. Many nerve troubles have their origin in utero, especially is this true of the contagions and infections. In fact many diseases of the fetal nervous system may be traced directly to this source.

There are three classes of nervous system diseases in regard to their etiology and pathology:

(a) Those in which the essential morbid element consists in a structural change in the nerve tissues, such as inflammation and degeneration.

(b) Those in which certain toxic agents affect the functionation of the neurons without producing any recognizable structural changes.

(c) Those which originate in purely psychic and mental conditions.

Disturbed nutrition is a prime result of demoralized nerve action.

Chapter XII

CONSTITUTIONAL DEGENERACIES DUE TO CHECK ACTION

Of Normal Structures in Man's Present Evolution

CONSTITUTIONAL degeneracy due to increased check action may be considered under three heads; first, those degeneracies which involve the normal structures in the existing stage of evolution as they pass through the periods of stress; second, those involving structures which were useful in adult lower vertebrates but only embryonic in man which Shute calls "useless scaffolding left in the body"; and third, involving those structures which are disappearing.

Before considering these types, it is necessary to have a clear understanding of what a degenerate is and what degeneracy means.

A Degenerate, then, is one with an unstable nervous system and whose physical development is a departure from the type, in the direction of lessened complexity.

An Unstable Nervous System is one in which higher centers are arrested or over-developed, either as a whole or as to powers of co-ordination, a fair sample of which is found in a one-sided genius or a moral imbecile.

Physical development departs from the normal when an organ or part of the body has become arrested or excessively developed at the expense of the whole organism.

An unstable nervous system may exist with all structures and organs normally developed, thus moral imbeciles and paranoiacs occur with normally developed structures. Here the structures and organs have gained at the expense of the central co-ordination of the nervous system.

Persons, having normal brains, may have degenerate organs and limbs; successful and mentally well-balanced men may have degenerate structures and organs. The higher nervous system has here gained at the expense of other structures.

A man is not necessarily a degenerate in the complete sense of the term because he possesses stigmata. Certain Italian and French viewpoints make a man a degenerate with eight or twelve stigmata, irrespective of the nervous normality present.

A Degeneracy is a badly balanced structure, arrested or excessively developed, or both. Degeneration is a gradual change of structures by which the organism becomes adapted to less varied and complex conditions of life.

Degeneracies in children take place at periods of stress because the nerve centers are then not properly co-ordinated and therefore unstable. Such degeneracies may remain throughout life and the brain later develop to normal. Degeneracies from post-natal causes may take place at the periods of stress even though the nerve centers of the previous stage be normally developed.

Nearly every kind of physiologic disturbance may occur at periods of stress from the influence of maternal nutrition, environment, personal congenital factors, or, after birth, from the infections.

Organs and structures checked at certain phases of development often pursue a course of development differing from that indicated in man, but allied to that designated in other vertebrates.

Stigmata. Degeneracy may be limited to certain signs which are its sole expression. These signs (stigmata) may be the only expression of degeneracy. Their true significance must be determined by a careful examination of the organism in which they are found, since they may be merely external defects produced by degeneracy, or may indicate how deep such degeneracy has penetrated. They may indicate slight or serious defect. In proportion to the depth of degeneracy, in the organism, will the stigmata affect the earlier or later complex states acquired through evolution.

Of necessity, when the organism is affected by degeneracy, the morbid process will take the line of least resistance, determined by the depth of degeneracy, as well as by the variability of the structures concerned and the nature of maternal and personal environment. The same influence equally affects functions of the structures. Expressions of degeneracy will be influenced by the periods of stress. These stigmata, generally speaking, are divisible into mental and physical. They are best observed in their relations to the periods of stress. In certain races, as in certain animals, pre-puberty conditions cannot be considered as settling the position of the animal in the scale of life. What is true of individuals is also true of classes. Anthropoid apes and negroes are much higher in physical characteristics, with potential and mental results, before puberty than after.

Artificial or accidental periods of stress may be produced, when the natural course of development would be otherwise uneventful, by disease, by intoxication, by various impunities of food, drink, infections, or by nervous changes resulting from mental anxiety or other emotional cause.

Nutritional Aspect of Development. Development of organs is markedly influenced by their functional activity. Increased function is followed by increased nutrition and by evolutional perfection of the functioning organ. This may cause a transmission of new characters to the offspring. Disuse leads to atrophy (arrest of development) but only after

a long period of disuse by successive generations do the apparently useless organs cease to appear. Degeneracy of some organs may be necessitated by the development of others. Thus prehensile development of the hand renders it less useful for locomotion. The reverse occurs in the foot. Development of the brain, by which inventions are created to do away with manual and physical labor, results in subordination of the physical man to the mental.

Because of the reversional aspect of physiologic atrophies and hypertrophies, Magnon and Legrain made the true but too radical assumption that degenerates are abnormal because of the inability to re-acquire progressive powers of primitive ancestors. There are here two factors, independent of the enormous one of environment, to be considered, viz., the impetus given nutrition toward the hypertrophied organ and the impetus of nutriment from the atrophied organ. For this reason evolution retrogression involves more than the simple retracing of the steps of normal evolution. This principle is illustrated in the diagrams of Magnon and Legrain, Fig. 63. The ascending lines represent the pro-

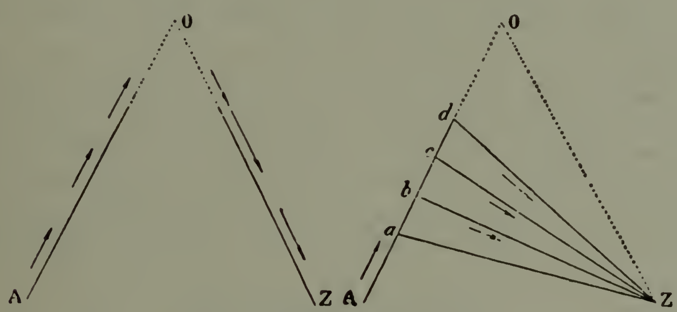


Figure 63
Diagram showing progressive and degenerative evolution of a structure or organ, (Magnon and Legrain).

gressive evolution of an organ or institution; the descending lines represent the degenerative or suppressive evolution. From the point a, representing the primitive condition, progressive evolution passes toward o, an imaginary perfect condition of the organ. Along the upward line, however, the points a, b, c, d, etc., represent obstacles to further progress—that is to say, factors tending toward degeneration. From these points lines of degeneration pass towards z, and the condition at z, although equivalent to that at a, is not identical with a, and is not reached by a sliding backwards down the line o-a. Thus, while most recently acquired features tend to disappear first, degeneration is not a complete retracing of steps

until the point of departure is reached, else arrest in development would result in complete annulment of all further progress.

In the evolution of the frog from the tadpole, certain structures are lost and others gained. This is true of all animals. By the permanent laws of nature, an animal must adapt its organism to its environment or become extinct. These structural changes take place according to environment. The same condition is true of man. In his evolution, man undergoes changes to suit his environment. Structures are lost and others gained to meet these requirements. This law, indicated by Aristotle, but clearly outlined by Goethe in 1807 and Geoffroy St. Hilaire in 1818, underlies the physiologic atrophies and hypertrophies which play such a part in degeneracy and evolution. Structures that are passing are called transitory or degenerate structures. Transitory or degenerate structures are more easily and quickly affected by disease than those which are gaining in function.

Evolutional Phases of Degeneracy. Specialization oftentimes results in further development of organs or parts; or certain organs or parts are used for other purposes changing their original form; or certain organs or parts disappear by atrophy. When these developments fail, abnormalities appear resembling those of the invertebrate and vertebrate types. Structures normal in invertebrates and vertebrates may remain in a rudimentary condition; or a structure normally transformed may retain its original form; or, finally, structures which normally perish by atrophy may fail to do so, and a fully-developed organ, normal in the lower animals, may thus atavistically reach full development in man.

Close study of degeneration shows why anatomic characteristics of man and apes are so intimately allied. Not that man sprang from the ape (though they have identical structures some of which are lost by atrophy or remain dormant in man) but that they have a common ancestor, which had the structures normal in the apes but atavistic in man. As already shown, every structure in the human body passes during its ontogeny through stages of the lower vertebrate types, fish, reptile, bird and mammal. Arrest or excessive development may occur during the period of stress at any one of these stages. Only a few of the more marked changes will be here considered.

Constitutional degeneracies, due to check action of normal structures in man's present evolution, include: durencephaly, degeneracies affecting bones of the body as a whole, the brain, neurons and connecting fibers, the hair, gill clefts and defective ears, supernumerary mammae and nipples, internal organs, uro-genital cleft, uterus and ovaries, non-descent of the testicles or cryptorchidism, degeneration of the bowels, spina bifida, deformity of the hip joint, club foot and hands, flat foot and obesity.

Durencephaly. Degeneracy which involves the normal structures of the body in the present stage of evolution as they pass through the periods of stress may begin in the prevertebrate types (Fig. 64). The

Figure 64
Durencephalous head of new-born child (original). This illustration shows an arrest in ontogeny of the cranium with an elephantine ear.

primary skull, as already stated, is an extension of the vertebrae, which send side outgrowths to cover the brain, as the backbone covers the spinal cord. In the lancelet, it gives off two trabeculae cranii or front skull plates. In the back, the primary skull (or chondrocranium) gives off two occipital or rear skull plates and two plates midway between the trabeculae and the occipital. These gradually close the primitive hearing apparatus,

Figure 65
Arrest of development of the entire body at eight years of age due to scarlet fever. The figure to the right, now forty-two years of age, contrasted with a normally developed man.

the otocysts (permanent in fish and embryonic in man) and are called periotic capsules. This primary skull is at first cartilaginous, as in sharks. With increase in size of the brain, in biologic evolution and in human embryogeny, the cartilaginous primary skull becomes insufficient to roof over the brain and gaps result. The extent of these gaps depends upon the amount of nutriment furnished by the mother for the development of the fetus. If sufficient material be not furnished, fontanelles and open spaces (Fig. 33) in the skull result. Often these spaces are filled with imperfect bone types, the Wormian bones (Fig. 34). The amount of

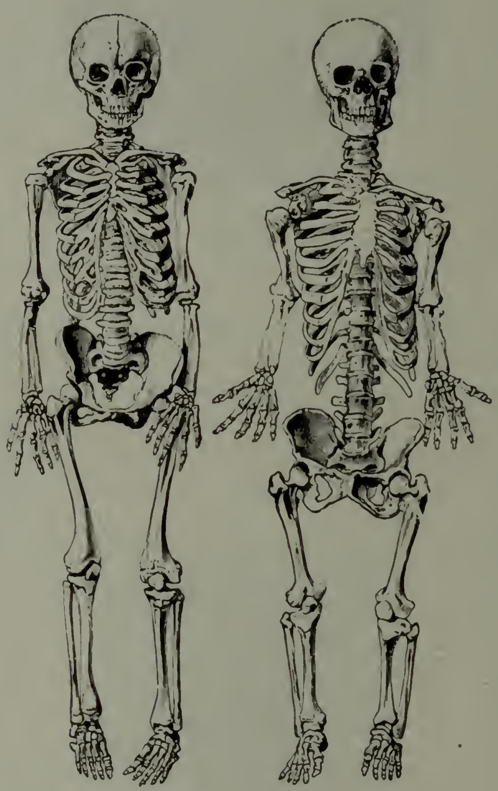


FIGURE 66

Figure to left, skeleton of a female cretinoid dwarf. (Age 31, height 118 centimeters) (Ziegler). The epiphysial cartilages of the long bones and pelvic bones persist, as also the frontal suture. The several parts of the skeleton are fairly proportionate, except that the upper extremities are relatively short. Figure to the right, skeleton of a female dwarf. (Age 58, height 117 centimeters). The bones of the limbs are very short, the trunk is relatively long. The epiphysial cartilages have not persisted, and the articular ends of the bones are thickened.

nutritive material may be so scanty that the entire dome of the skull remains undeveloped (Fig. 53).

Degeneracies Affecting Bones of the Body as a Whole. Arrests of the body as a whole may take place in utero from the unstable nervous system of the mother, her imperfect nutrition or autointoxication. Arrests of the child after birth often arise from constitutional diseases, more particularly the eruptive fevers. All constitutional diseases affect children to a greater or less degree, sometimes for a week, month, year or for life. Fig. 65 shows a person forty-two years of age whose development became arrested at eight from scarlatina. Different parts of the body are often disproportionately developed. Thus the trunk may be arrested or excessively developed (Fig. 66). The limbs may be short or long to correspond with deficiencies or excesses. The bones upon one side of the body may be larger than on the other. Occasionally the limbs are unusually short, the hand may be developed at the elbow or shoulder, the foot at the knee or hip. These arrests simulate the flipper of the seal or whale. Excessive development of the arms is sometimes noticed, they often develop to the extent that the tips of the fingers extend below the knee as in apes, Fig. 67.

a. *b.* *c.* *d.*

Figure 67

Skeleton of anthropoid apes and man (Huxley). (*a*) orang; (*b*) chimpanzee; (*c*) gorilla; (*d*) man. The contrast and evolution of the head and jaws is striking. The front legs or arms are also noticeable in regard to length. The shortening of the fore limbs as we advance in evolution, due to environment, is pronounced.

The human limbs are developments from the fin-folds as found in fish, reptile, bird and mammal. In one of these, the fins are divided into four segments. The upper segment contains one long bone, the humerus (or arm bone), or the femur (or thigh bone). The second segment con-

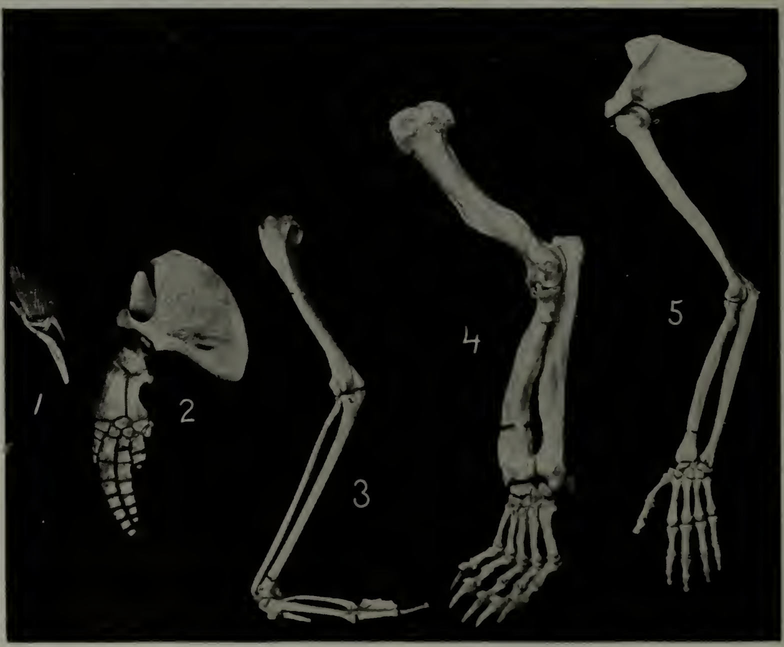


FIGURE 68
The evolution of the limbs from the fin (Carnegie Museum). (1) is the fin of the fish. The rays are numerous, many jointed, slightly flexible and capable of lateral movement only. The arm bones are short, broad and thin and the entire organ is so constructed that it is only adapted for swimming purposes. (2) The swimming paddle of the dolphin in which the phalanges are separated from one another by intervening cartilages and on the elasticity of which the mobility of the manus depends. The radius and ulna are parallel to each other capable of rotation. (3) The bones in the wing of the bird adapted to flight only. The humerous articulates with the radius and ulna by a slightly oblique joint. There is practically no rotation of the manus and in this part the carpal bones are reduced in number. All the bones of the limb are evidently adapted for supporting the quill feathers and for free flexion only in the direction of folding or extending the wing. In (4) that of the lion, the entire mechanism of the foot is developed to produce a rapid, light and springy gait and to protect the tips of the claws from unnecessary wear. (5) Prehension in which is attained the greatest possible mobility compatible with the presence of long inflexible bones is well typified by man. All the joints are so arranged that the hand is capable of movement in most any direction. While there is a similarity in each limb, each has developed for some particular purpose. The purpose, however, is more complicated, the higher the advance in phylogeny.

tains two long bones, the radius and ulna (or forearm bones), or the tibia and fibula (or leg bones). The third segment consists of nine small bones, the carpals of the wrist or the tarsals of the ankle. The fourth segment consists of five separate digits. These limbs pass through stages in phylogenetic development according to their position, shape, length and function which may be designated as fish, reptile, bird and mammal types, Fig 68. Many of these bones fuse together (carpals and tarsals). The digits have, long before the fish stage, been formed of more than one bone. At times, this condition persists even after the completion of human embryonic development. Limb anomalies resulting from checks of development causing either excess or arrest of development are far from uncommon in degenerates but are not so common as anomalies of form and proportion, Fig. 69.

FIGURE 69
"Pepin" (Gould and Pyle). The hands and feet are fairly developed while the bones of the arms and legs are arrested in phylogeny.

Sometimes the arms develop completely while the lower extremity remains in the fin-fold state. On the other hand, the arms may be checked and remain in the fin-fold state while the legs go on to full development. Sometimes the bones of the arms and legs are checked while the digits go on to full development. The lower extremities are sometimes fused together. This condition, from its resemblance to the like state in the seal, is called phocomelia or seal limbs, Fig. 70.

Achondroplasia, or imperfect development of cartilage with resulting imperfections in the extremities, sometimes occurs. A man of thirty-

eight years, had a face arrested in development producing the appearance of a ten-year-old boy. His jaws were small with a protrusion of the lower.

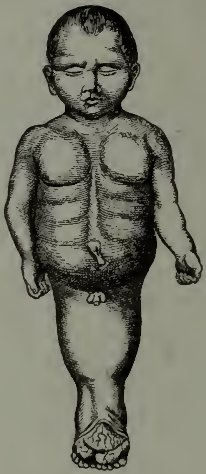


FIGURE 70
Example of siren (Gould and Pyle). Shows fusion of the lower extremities.

His arms were absent. The hands were full sized and attached to the shoulder. In a member of the Spanish nobility, degeneracy was stamped on the entire body. He was short in body and had an enormous head. The jaws were undeveloped with a V-shaped arch. His left hand was located near the shoulder.

Supernumerary fingers and toes are not uncommon. Darwin regarded them as atavistic.

THE BRAIN, NEURONS AND CONNECTING FIBERS. The most marked distinction between man and the lower animals is in his brain. In man, this higher organ has grown to be three times larger than the brain of the highest apes.

With a cerebral surface, and a corresponding intelligence, far greater than that of other mammals, anthropoid or tailless apes begin life as helpless babies and are unable to walk, to feed themselves, or to grasp objects with precision until they are two or three months old. At this period, they are able to care for themselves. These apes have thus advanced a little way upon the peculiar road which the forefathers of man began to travel as soon as psychical variations came to be of more value to the species than variations in bodily structure. The gulf by which the lowest known man is separated from the highest known ape consists physiologically in the great increase of his cerebral surface, with the corresponding increase of intelligence, and in the very long duration of his infancy. These things

have gone hand in hand. Increase of cerebral surface has entailed a vast increase in cerebral organization that must be completed after birth, which thus has prolonged the period of infancy. Conversely the prolonging of the plastic period of infancy, entailing a vast increase in teachableness and versatility, has contributed to the further enlargement of the cerebral surface. These mutual re-actions have gone on for an enormous length of time, since man began diverging from his simian brethren.

Reversions and defects in brain growth are numerous. The classification of brain defects has been discussed in Chapter IX. In passing, it is only necessary to say that brain arrests and excessive development take place like those of any structure in the body. Excesses or arrests as a whole, in brain areas, in nerve cells, or in connecting fibers render him more highly developed or cause simulation of the lower vertebrate types. Even the cells of the cortex, with their prolongations, pass through the fish, reptile and bird types in their development. The folds of the cerebral cortex, from a lack of healthy normal stimulus, sometimes revert to forms resembling those found in other groups of the animal kingdom.

Hair. In the development of the fetus from the fifth to the seventh month, the body, except the palms of the hands and the soles of the feet, is covered with a thick hairy coat. It is claimed this coat is shed at birth but whether this be true or not, there is a coat of fine short hair over the body throughout life. This covering is called lanugo and is atavistic, since the apes (man's nearest ancestors) have hair over the entire body;

Figure 71
Excessive hair growth (Ziegler).

Figure 72
"Jo-Jo" (Gould and Pyle).

it is therefore a simian characteristic. All human beings have an excessive development of hair on different parts of the body, occasionally developing to large proportions. When man passes through the first

period of stress, arrest takes place at the anthropoid ape stage and the hair develops at the expense of other organs (Fig. 71), where it simulates the lower ape. There are many noted instances of this development.

Some years ago, a person exhibited under the name of "Jo-Jo, the dog-face boy" (Fig. 72), had a true sky terrier face. A child, a native of Indo-China named Krao, had her entire body covered with black hair. Many other similar cases are on record.

True alopecia (the condition of being born without hair), while it is rare, does occur. Thus Danz knew of two adult sons of a Jewish family, who never had hair or teeth. A number of other cases are mentioned by Gould and Pyle.

Gill Clefts and Defective Ears. The failure of a structure to become suited to new uses is seen in the persistence of gill clefts. These, serving the fish to admit water holding air in solution, change to other structures in air breathing animals. When the adaptation fails, the anomaly of an opening through the neck into the throat is exhibited. An attempt to swallow liquids causes them to pass through this opening, thus illustrating how a phase of evolution useful and necessary in fish and amphibians is a serious danger when it occurs in man.

Man, in his evolution from the lower metazoa, passed through the fish type stage. The breathing apparatus of the fish consists of gills with bars across them upon which fleshy curtains are hung, through which blood circulates. These bars or arches are from five to seven in number in many fish. These slits are open and unprotected in sharks. In modern fish, they are protected by a lid. When the fish-like ancestors of man left the water, this elaborate breathing apparatus was no longer needed for respiration. The first gill slit and portions of its adjacent bars were completely changed for the purpose of hearing. Human ears, therefore, were in this manner developed. There are two passages in connection with the ear; the external auditory canal extending to the membrane or drum and an internal passing from the throat towards the drum. These canals are similar to the first gill slit of the shark. In degenerates, the external ear may be entirely wanting, an opening alone being present. The ear may be normal and the opening, with a supernumerary ear, be located lower down the neck at one of the other gill clefts.

The external ear, is, of all organs, most commonly affected by degeneracy. Being a cartilaginous organ extending from a bony base, without a bone frame-work for its support and with very deficient blood supply owing to its distance from the great blood centers, any defect in the nerve centers which control the local blood supply is likely to affect its nutrition. On account of its being a cartilaginous organ, it has no lymphatics, necessarily affecting its growth. The sensitiveness of the ear to vasomotor changes

is evident by the results of the extremes in heat and cold, emotional blushing and fatigue. Galton reports a school mistress who judges the fatigue of her pupils by the conditions of their ears. If the ears be white, flabby and pendant, the children are much fatigued. If they be relaxed, but red, they are suffering, not from over-work, but from a nervous system struggle rarely under control in children. These states are common among degenerates.

To appreciate the degeneracy observed in the ear, its embryogeny must be studied. Before the end of the first month, there appears around the external opening of the first gill-clefts, a series of six tubercles, two in front on the hind edge of the first visceral arch, one above the cleft and three behind it (Fig. 73). A little later a certical furrow appears down

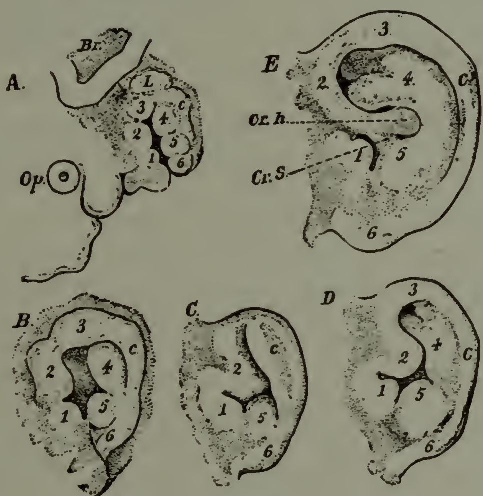


FIGURE 73
Development of the ear (Minot). Shows the successive changes in embryonal ear development.

the middle of the hyoid arch, in such a way as to mark off a little ridge which joins on to tubercle three and descends behind tubercles four and five. The second stage is reached by the growth of all the parts; the fusion of tubercles two and three and the growth of the ridge down behind tubercle five to become continuous with six. After these changes, it is not difficult to identify the parts.

Tubercle number one is the tragus; two and three together with the arching ridge, represent the helix; four the anti helix; five the anti tragus and six the lobule; the pit between the tubercles the fossa angularis. During the latter part of the second month, the ear changes in its propor-

tion somewhat in the irregular development. The third stage begins at the third month. The upper and posterior part of the concha arises from the surface of the head, and gradually but rapidly bends forward so as to completely cover the anti-helix and the upper portion of the fossa angularis. During this stage in mammals, the assumption of the pointed form of the ear commences. The fourth stage begins at the fourth month, when the tubercles, which are now joined together by cartilages, commence to unfold and are completed by the fifth month. Finally, the sixth tubercle develops to form the lobule. This unfolding or development of the tubercles to produce the different portions of the ear and make it complete is not unlike the development of a flower from the bud. By this process may be understood how if, by malnutrition in one tubercle or bud, or should there be a larger supply of nutriment in one than another, malformation of the ear would result. If arrest of development of all the tubercles should take place at any period, from the first to the fifth month of fetal life, the ear would resemble a semi-developed flower.

As in other cases, it is necessary to fix an approximately normal standard for the ear from the standpoint of man's status in evolution. The ear grows more or less through life, but, like the skeleton, practically reaches its full development about the twenty-fifth year.

A normal ear (or rather the ideal ear, for few possess it in its entirety,) should have a gracefully curved outline, nowhere pointed or angular, with a well defined helix, separated from the anti-helix by a distinct scaphoid fossa extending down nearly to the level of the anti-tragus. Its root should be lost in the concha before reaching the anti-helix. The anti-helix should not be unduly prominent and should have a well marked bifurcation at its superior extremity. The lobule should be shapely, not adherent or too pendulous and free from grooves extending from the scaphoid fossa. The whole well shaped and properly proportioned. In the adult, we may say that it ought not to average much over two and one half inches in length and one and one fourth in breadth.

It is very rare to find a normal ear. The most marked deformities are those in which they resemble the ears of lower animals. Thus in Figs. 64 and 74, we have the elephantine ear; in Fig. 75, the Darwinian ear with the pointed outer or inner rim. Darwin, struck by the frequency of this tubercle, believed it to be remnant of the pointed ear of lower vertebrates. Deformities of the ear, unlike many other deformities of the head, are always seen at birth, although perhaps not so prominently as later in life. Not infrequently, the ear is found located forward, again backward, high or low upon the head. The two ears vary in position in the same individual, one ear often higher and placed more forward than the other. The ears of the negro are frequently arrested in development

and are often deformed. Occasionally one ear will be markedly deformed while the other is normal in development.

FIGURE 74
Elephantine ear (original). This shows arrest of development of the ear in phylogeny.

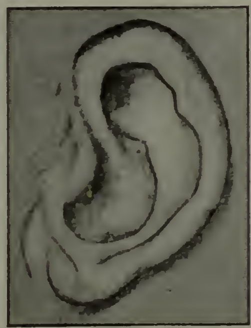


FIGURE 75
The Darwinian ear (Darwin).

SUPERNUMERARY MAMMAE AND NIPPLES. Supernumerary mammary glands and nipples are not uncommon in man as well as among the lower animals. They may appear on the chest, abdomen, axilla, arm, shoulder, cheek, buttock, leg and other parts of the body. Cases of ten have been observed. Annie Boleyn, the wife of Henry VIII, is reported to have had six toes, six fingers and three breasts. In the Louvre, in Paris, may be seen a picture, by Rubens, of a woman with four breasts. Leichtenstern has collected seventy cases in females and twenty-two in males of supernumerary breasts and nipples and believes that the accessory breasts or nipples are arrests in phylogeny. He says that the more remote, inferiorly organized ancestors had many breasts but that by constantly bearing one child, human females have gradually reduced the number to two.

Investigators report a man with six distinct nipples arranged as regularly as those of a bitch or sow. The two lower were quite small. This man's body was covered with heavy, long hair, making him very conspicuous when seen naked during bathing. The hair was absent for a space of nearly an inch about the nipples.

Many cases are on record where lower vertebrates have supernumerary breasts, located in different parts of the body like the human. Bland Sutton has shown that lemurs and monkeys have supernumerary glands in different parts of the body like those of the human. It would seem, therefore, that supernumerary mammae and nipples, in the human, were arrests in phylogeny at the lower vertebrate period of development, hence atavistic.

Milk is not infrequently formed and children nourished from these supernumerary mammae.

Uro-Genital Cleft. It is not uncommon to find degenerates (whose parents were relatives before marriage or who possess markedly exhausted reproductive organs) without an anus and with an opening from the rectum into the vagina and bladder. Sometimes both external genitals and anus are wanting. This phenomenon is easily explained in the formation of the uro-genital tract. Before the second fetal month, the alimentary canal and the spinal cord of all vertebrates arise from a common origin. At this period, the primitive gut tube becomes enlarged in the locality of the allantois to form a common space, the cloaca. The hind gut, the allantois, Wolffian ducts and the post anal gut extend into this opening.

The entoblast and ectoblast membranes form a delicate partition separating the ventral wall of the cloaca, dividing it into a posterior portion which forms the lower part of the rectum; the anterior is continuous with the allantois and receives the uro-genital ducts. It is this partition which is sometimes arrested in development which leaves an opening into the bladder and vagina, the fecal matter thus passing into the bladder and vagina, Fig. 76.

Figure 76
Anus is absent; rectum ends in the vagina (Ball).

In birds, reptiles and monotremes, this opening is constant. The occurrence of the opening in man, therefore, is an arrest in phylogeny at the sauropsidian stage of development. The lower bowel may be deficient as far up as the superior third of the sacrum. When this is the case, a surgical operation is almost impossible. In a child who lived nine days, the sigmoid flexure of the colon terminated at the end of the bladder, Fig. 77.

In a case reported by W. C. Bullard, when the girl was born it was discovered that there was no anal orifice and she was given up to die by the physicians. After a few days straining, a small amount of meconium escaped from the vulvar orifice. This increased in quantity and she began to thrive, but had great trouble with her bowels until 1888. For the past

few years, she has not been troubled beyond the fact that when the bowels are loose she cannot control the movements well, hence she sometimes soils her linen. When the bowels are not loose she has no trouble,

FIGURE 77
Anus is absent; rectum ends in bladder (Ball).

but must go to stool on rather "short notice." For a few months (August, 1908), at irregular intervals, she experienced vague pains in her back and abdomen, which she thought were caused by menstruation.

Examination revealed, extending from the fourchette posteriorly for about two centimeters and about one centimeter in breadth, a band of delicate skin, very closely allied to mucous membrane. From this back to the tip of the coccyx, the appearance was that of a normal perineum, the skin containing the usual amount of pigment, but no signs of an effort at the formation of an anus. The ostium vaginae, to the finger, seemed at first quite normal but after the finger had penetrated about three centimeters, it came in contact with an annular constriction which was evidently the internal sphincter of the rectum. When told to contract the sphincter, its grasp was quite perceptible, but had nothing like the force of the normal muscle. Just beyond this the finger came in contact with well-moulded feces and quite a roomy rectum. Bi-manual palpitation disclosed a narrow band running from one side of the pelvis to the other. On the left side, a quite movable body could be felt, which appeared about half the size of a normal ovary. This is undoubtedly a rudimentary ovary, as pressure on it causes that peculiar sensation complained of when the normal ovary is pressed. On the right side, occupying the same relative position, was a small firm body about one centimeter in diameter. This was, no doubt, the rudimentary right ovary. There was no evidence of a uterus, except the narrow band which crosses the pelvis, corresponding to the upper border of the broad ligament. The bladder was normal in every respect and a small speculum introduced showed the mucous membrane to resemble that of the rectum.

Cloacal but ovaro-uterine perfect women are so common that the

question of delivery is not an infrequent obstetric problem. The cloacal state is here essentially sauropsidian.

Excessive and Arrested Development of the Uterus and Ovaries. Occasionally, absence of the uterus and ovaries and fallopian tubes are reported. Sections of female subjects in whom the internal reproductive organs are wanting have been observed. In one case, the uterus and vagina were absent; in another, the uterus and vagina were absent and the kidney and bladder were deformed. Double uteri are occasionally reported with a single ovary and a fallopian tube for each. Fig. 78 shows arrest of development of the uterus and follicles with normally

Figure 78
Arrest of development of the uterus (Ziegler).

developed ovary. All the marsupial and lower types are found sometimes in women, also showing an arrest in phylogeny.

Non-Descent of the Testicles or Cryptorchidism. According to C. Moullin, normal descent of the testicle occurs in the eighth or ninth month of fetal life, the left one first, the right shortly before birth. In some animals, it is the same. In highly organized mammalia, the testes never come down at all. In the majority, they do not come down until the period of sexual maturity is approaching. In many, they come down only during the period of sexual activity. For the greater part of the year, they remain in the abdomen, and are comparatively insignificant in size. With each recurring sexual period, they increase enormously in bulk and descend into the scrotum for the time. At the end of the period, they go back into the abdomen and resume their former size and quiescent state. Here descent of the testes, increase in size and assumption of the functional activity are simultaneous events regulated by the same cause. In man,

the same three events occur as in these animals, but not as a rule, simultaneously. The testes descend before birth, while still retaining infantile proportions. Increase in size and assumption of functional activity take place later. The origin of this difference is to be found in the assumption of the erect attitude and the consequent necessity for early closure of the inguinal canal. Clearly it would not be for the advantage of the race were the tunica vaginalis to remain widely open, leading vertically down from the bottom of the abdominal cavity, until sexual maturity had been attained. A tendency to the same condition occurs among the old world apes. The events are the same only the time relations are altered. Every now and then an exception occurs. Occasionally in man, one or both testes remain in the abdomen and do not of their own accord descend into the scrotum. The retention in the inguinal canal interferes frequently with the internal secretion function of the testicle so that the child's mental and physical growth is, as Kiernan points out, arrested. The replacement of the testicle in the scrotum, as A. E. Halstead has shown, by an operation will stimulate mental and physical growth as much as thyroid feeding does in the cretin. All these conditions found in man are arrests in phylogeny.

Degeneration of the Bowels. Variations in size in development of the intestines at birth is not uncommon. They may be developed to the extent that they are a solid cord or may be distended so lightly as to be incapable of functioning or they may become excessively developed. Fig. 79 shows the degenerate small intestine of a new born child, (a) greatly

Figure 79
Arrest of development of the intestine (Ziegler).

distended portion, (b, c, d, e) showing arrest of development, (f) normally developed portion. These are arrests in ontogeny.

Spina Bifida. One of the striking conditions of degeneracy or arrest of development, is that in which the development of the bones enclosing

the spinal cord is checked. The spinal cord is at first essentially a notochord, as in the lowest types of vertebrates. The structures surrounding the cord are not divided into vertebrae. This condition is permanent in the lancelet. Around the notochord is later formed a species of membrane which protects it, called the perichord. This condition is the second stage of development of the cord and is the permanent condition in the lampreys. Later still the cartilaginous vertebrae develop, and then these ossify at the point in the perichord which is to form a vertebra, from which bows of dense tissue unite behind. In front, similar bows form to constitute the bodies of the vertebrae. These bows remain ununited in some of the lower fish and at certain stages in the human embryo. As degeneracy checks the union of the bows of the vetebrae, imperfection and even absence of the union occurs, which constitutes the condition known as spina bifida (Fig. 80). This condition when complete is rarely compatible with life.

Figure 80
Spina-bifida (W. A. Pusey).

In a partial state it is often found among degenerates and is an arrest in ontogeny. The seat of the trouble is frequently covered by an excessive development of hair (hypertrichosis), especially in the small of the back; this, which occurs very frequently in degenerates, resembles the tail which the ancients represented as that of the fauns (Fig. 81), and is an arrest in phylogeny.

Deformity of the Hip Joint. A marked degeneracy sometimes seen in a child is that in which the head of the femur has not its proper relation in the acetabulum at birth. When man walked upon all fours, the body was supported by four instead of two legs. The weight of the body was

thus distributed. In his upright position, the bones of the leg and the thigh of man are much heavier and more sensitive than in the ape. The thigh bone or femur is the largest and heaviest in the entire skeleton and

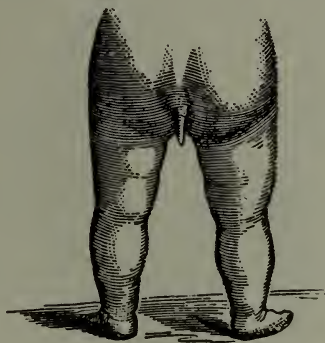


FIGURE 81
Caudal appendix observed in a child (Clinic of M. Gosselin, Gould and Pyle).

twice the size of the same bone in lower animals. The head of the femur articulates with the pelvis bone in a cavity called the acetabulum. The acetabulum is made up of three bones; the ilium, the ischium and the pubis. The shape of the rim of the cavity is not unlike that of a horseshoe; the two ends pointing downward whether the animal be on all fours or in an upright position. When the animal is on all fours the middle of the horseshoe is divided between the ischium and ilium. When in an upright position the middle of the horseshoe is entirely in the ilium, the rim having changed its position, thus giving support to the weight of the body. Occasionally, the rim of this cavity becomes arrested in its phylogeny (Fig. 82), at the anthropoid ape period leaving the cavity without support to the femur.

CLUB FOOT AND HAND. Among expressions of degeneracy, oftentimes secondary, however, are club foot and hand. In this deformity, the sole turns inwards and upwards with the heel raised.

In many instances, these retentions of positions are assumed by the limbs of the fetus in the course of evolution and therefore, are, in the adult, expressions of degeneracy. It is an interesting fact that club foot is normal in the apes. Every child's foot must pass through this ape phase and if it ceases to develop at this stage it must be considered that the child retains its ape-like characteristics, and hence is an arrest in phylogeny.

Club foot was an expression of degeneracy in Byron, the poet, as Kiernan has shown. Commenting on this condition as found in Byron, F. S. Coolidge, remarks that "Byron undoubtedly suffered from double

congenital club foot, the deformity being worse on the right." While in Coolidge's opinion congenital club foot unquestionably arises from different causes, it is, however, so frequently an accompanient of severe

FIGURE 82
Arrest of the rim of the acetabulum (Ziegler). *A*, old acetabulum without rim. *B*, new articular cavity.

forms of mal-development and of congenital brain defects, that there can be no doubt but that imperfect constitutional development is one of its causes. That the deformity, with the many limitations which it involves, may tend to create morbidness is very likely to be an additional symptom of degeneracy which, in certain cases, is the underlying cause of the deformity. Dareste, who has studied the club foot and hand from the standpoint of experimental teratology, finds that in no small number of cases club foot and hand result from checked development at the ape stage.

FLAT FOOT. Since the immediate lower vertebrates walk on four feet, the weight of the body is thus distributed. In man's upright position, the entire weight of the body is centered on his two feet. To prevent jar to the body, the foot is formed into an arch. The plantar muscles, fasciae and ligaments, especially the inferior calcaneo-scaphoid, assist, together with the bones of the foot, to form this arch. The weight, therefore, comes upon the calcaneum forming the heel and the bones of the toe.

From the flat foot of the anthropoid ape and lower negro type, as we ascend in the evolution of man, it becomes more arched (Fig. 83). When, therefore, man is flat-footed, it is an arrest at the anthropoid ape stage.

It is a marked stigmata of degeneracy and is associated with grave moral defects and intellectual distortions. It is frequently found among paranoiacs, moral imbeciles, prostitutes, and "smart" business men.

FIGURE 83
Flat foot (original). This illustration shows the evolution of the foot from the anthropoid ape and lower negro type.

OBESITY. Obesity or lipomatosis is a nutritive expression of degeneracy especially noticeable in the second dentition, at puberty, and sometimes at the climacteric. As Féré has shown, lipomatosis is an expression of stress at the period of evolution. Youthful obesity occurs in descendants of degenerates. In my experience, it is attended by great liability to disease and systemic weakness when under morbid influence. These lipomatosic children are liable to rheumatism (more properly gout) and hemorrhage from slight causes. Youthful obesity is sometimes, as Féré remarks, associated with precocious maturity and resultant early senescence, but more often with extended infantilism, as in the case of Dickens' "fat boy."

Obesity, when associated with the acid states, is often the result of school strain. The apparent improvement shown in increased weight leads to increased strain, and many of these fat victims of school overpressure enter insane hospitals at puberty as lunatics.

Historic archives inform us that in some countries, it is considered a beautiful female adornment to be a shapeless mass of fat. From the same

authority we learn that Moorish women become very fat upon a diet of dates and a certain kind of meal.

Kiernan has shown that while fat is but an expression of the imperfect burning up of energy food, it is frequently associated with genius from the irregular life-producing suboxidation in the acquired cases and the effects of strain at the periods of stress in defectives. It is often found, therefore, where degeneracy co-exists with genius. One of the signs of the depth of degeneracy in the maternal side of Byron's family appears in the premature obesity of his mother, which same stigmata was apparent in Byron himself which worked, together with club foot, for Byron's discomfort. Victor Hugo, Theophile Gautier, Rossini, Jules Janin, Alexander Dumas, Balzac, and many others are in this category.

That the lower animals pass through many changes in their evolution and that arrests in phylogeny occur in the higher species, the following case will demonstrate. The primitive horse (Eohippus) of North America, which was the size of a fox, possessed four well developed fingers and a rudimentary fifth, the thumb; in the two next higher animals (Orohippus and Epihippus), the size of sheep, the thumb bones have disappeared, the four remaining fingers persisting; in the next higher (Mesohippus), only three fingers are well formed the fourth merely exists as rudimentary; in the Michippus, it has become still smaller; in the Portohippus of the Pliodene, the fourth finger has entirely disappeared and three only persist. This animal corresponds to the European Hipparion and is about the size of the ass. Another Pliocene form still higher in the scale of evolution is the Pliohippus with the second and fourth fingers extremely rudimentary, the third much more highly developed. The modern horse has the third fingers largely developed and specialized, the second and fourth being very rudimentary. This aptly illustrates the law of economy of growth whereby an organ or structure is lost for the benefit of the organism as a whole.

It was my good fortune to observe a horse in the streets of Chicago with four well developed supernumerary hoofs, located on the inner side of each leg. An arrest in phylogeny at the early Eocene period of horse development. This animal was a degenerate beast in every respect. The animal has sacrificed material needed for other purposes for the benefit of the hoofs.

Summary

Degeneracies due to increased check action involve: (1) structures in the evolutional stage prevailing at the time of stress, (2) vestigial rudimentary structures, and (3) transient structures.

A degenerate is an individual whose development reverts to less complex types, due to an unstable nervous system.

An unstable nervous system is one in which the co-ordinating influence of the higher centers is either arrested or over-developed, in relation to the normal state of balance.

Arrest or over-development of a part at the expense of the whole constitutes degeneracy.

This unbalance may occur as between the nervous system and the body as wholes, either gaining at the expense of the other.

Strictly speaking, every individual is a degenerate, the condition of absolutely normal balance being an ideal one. Just what degree of unbalance constitutes clinical degeneracy is a mooted point.

Arrests and over-development of normal organs occur at periods of intra- and extra-uterine stress. The expressions of such degeneracy will be influenced by the original and succeeding periods of stress. They are generally divisible into mental and physical stigmata.

Degeneracy due to arrest or over-development involves more than the simple retracing of the steps of normal evolution; a new factor enters into the equation in the impetus given to nutrition toward and away from the over developed and arrested organ respectively.

Arrest of development manifests itself in abnormalities corresponding to the evolutional type prevailing at the time of arrest, and these may assume one of the following forms: (a) Structures normal in lower types may remain in rudimentary condition, (b) Structures which are normally transformed may retain their embryonic form, (c) Structures which normally disappear may persist.

The systemic unbalance which gave rise to arrest may in later life right itself, and the degeneracy to all practical intents be remedied; or it may persist and manifest itself in various directions at periods of stress; depending upon the profundity with which the organism is affected.

The most prominent forms of degeneracy due to arrest of normal structures in man are as follows:

Those affecting the bone development of the skull (durencephaly).

Those affecting the bone development of the body as a whole.

Those affecting the brain and neurons.

Anomalies of the hair.

Gill clefts and defective ears (exceedingly common).

Supernumerary organs (mammae and nipples).

Infantile or undeveloped internal organs.

Non-descent of testicles (cryptorchidism).

Degeneration of the bowels.

Spina bifida.

Deformity of the hip joint.

Club foot and hand.

Flat foot.

Obesity and many others not enumerated here.

Since all these degeneracies are, as already explained, most often brought about through disturbances of the central co-ordinating nervous system, they are frequently found associated with mental and psychic abnormalities. Sometimes the expense is on one side and sometimes on the other, so that with these deformities one sometimes finds deficient and sometimes excessive brain development.

Chapter XIII

CONSTITUTIONAL DEGENERACIES DUE TO DECREASED CHECK ACTION

Of Structures that have passed in man's present evolution

STRUCTURES which have become useless during the evolution of man that Shute calls "useless scaffolding left in the body" are the ear muscles, tail, tail muscles, great toe muscles, grasping power of infants, pineal eye and gland, cervical and short ribs and vermiform appendix.

Ear Muscles. The three muscles of the ear are the attrahens, retrahens and attollens auren. These muscles, in the vertebrates, move the ears in different directions to detect sounds, while the animals are eating, without moving the head. Man, in his upright position, uses all his senses. He, therefore, moves the head in order to hear as well as see. Disuse, therefore, has arrested these muscles in development. Occasionally, these muscle arrests in phylogeny become potential at periods of stress and man by training them can move the ears.

Tail and Tail Muscles. The tail, a very variable organ in biology, appears only to disappear in the higher crustacea (crabs). It likewise appears only to disappear in the higher ichthyopsidae (frogs and toads).

Virchow, discussing the presence of the tail in man (Fig. 81), points out that sacral trichosis (hairiness) is related to this condition. Sacral trichoses, represented by a tuft of hair, is all that is found in the anthropoids. Virchow found, in such tails as he was able to examine, no vertebral elements, but merely a central canal representing the chorda dorsalis. Embryologists have found nothing but the chorda and atrophied medullary tube in the caudal appendage which is present in all human embryos at a certain period of life.

A family in which the tail appeared for generations was reported in 1888 by a Russian ethnologist, fulfilling Virchow's prophecy, made in 1880, that such conditions would be found among the lower Mongolic and Negroid races.

A certain Wesleyan missionary, George Brown, in 1876, spoke of a formal breeding of a tailed race in Kali, off the coast of New Britain. Tailless children were slain at once, as they would be exposed to public ridicule. The tailed men of Borneo are people afflicted with hereditary malformation analogous to sexdigitism. A tailed race of princes have ruled Rajoopootana and are fond of their ancestral mark.

The bone immediately below the sacrum, called the coccyx, is the essential representative of the tail in man. At a certain stage of human

development, as in the tadpole, the tail disappears, the nine vertebrae forming the coccyx unite together and become a very diminutive bone which loses nearly all vertebral characteristics. Sometimes this bone retains its embryonic peculiarities to such an extent that in some degenerates it is a rudimentary tail. There are races in which, as Virchow points out, the tail has a tendency to appear more frequently than in others. Sometimes children are born tailed.

This condition has been found to occur with comparative frequency among the negritoes. In this respect, these people are below the anthropoid apes, in whom the tail, considered from the tail standpoint, has degenerated, as in man, for the benefit of the organism as a whole.

The tail muscles, still found in the human embryo, have become bands of fibrous tissue. They are occasionally discovered, fully developed, in the dissecting room, an arrest in phylogeny.

Great Toe Muscles. In man's evolutionary flight, he falls more and more away from his ape-like conditions. This is especially noticeable in the differentiated use of the hands and feet, which in the apes are used alike for grasping and locomotion. In some respects this tendency is lacking in certain races, who use the foot for rowing.

In man, the muscles which enable the apes to oppose the great toe with the others, or the Opponens Hallucis, are entirely wanting. Man, in his evolution, uses the feet more for locomotion and less for grasping. Therefore, when man arrives at his highest type we find this muscle has entirely disappeared through disuse, under the law of economy of growth.

Grasping Power of Infants. Under the influence of deficient check action in ontogeny, not only are organs and structures retained, but potentialities occur in infants which indicate a persistence of the tendencies of the early race. When man lived in trees, he had a highly developed grasping power of the arm for clinging.

Dr. Louis Robinson "tested a large number of new born infants in reference to this power by extending his finger or a cane, to imitate the branch of a tree and observed how long they would hang there without support (Fig. 84). He made experiments on about sixty children under a month old. About thirty of the children were not over an hour old. All but two were able to hang to the finger or cane by the hands, like an acrobat from a horizontal bar, and sustain the whole weight of the body for at least ten seconds. Twelve, less than an hour old, held on for half a minute, before the grasp relaxed. Four held on for one minute. Over fifty of the infants four days old could grip half a minute. Three weeks after birth the power of holding reached its maximum. At this age several hung for a minute and a half; two held for over two minutes; and one over two minutes and a half. One less than an hour old hung by both hands to

Dr. Robinson's finger for ten seconds. It then deliberately let go with the right hand, as if to seek a better hold, and continued its grasp with the left hand for five seconds longer. In none of these experiments did the

FIGURE 84

Illustrating the grasping power of infants (photographed by Dr. Louis Robinson). (Shute). Two infants ten and thirteen days old respectively, supporting their weight by the hands.

limbs hang down in the attitude of the erect position. The thighs were invariably in the baby-monkey attitude, at right angles to the body. This attitude and the disproportionately large development of the arms compared with the legs give the photographs of the infants a striking resemblance to the celebrated chimpanzee, Sally, of the London Zoological Garden. The infants very seldom gave any sign of distress and uttered no cry until the grasp began to give way. The fact that the flexor muscles of the forearm of a new born infant show such remarkable strength while the other parts of the muscular system are so conspicuously weak and flaccid —that they are able to perform a feat of muscular strength that will tax the powers of many a healthy adult—can be explained only on the theory of inherited potentiality from simian ancestors which lived in trees. This is no longer useful but is a vestigial potentiality, a useless scaffolding in its life history."

THE PINEAL EYE AND GLAND. Perhaps the most striking instance of the sacrifice of an organ in local degeneracy for the benefit of the body as a whole is the pineal eye and body. In the remote ancestors of the

vertebrates, the acidian, the amphioxus, the slow worm, some lizards and the horned toad, there is a single eye in the center of the forehead (Fig. 85).

FIGURE 85
Head of a lizard or horned toad (W. S. Atkinson). Showing translucent pearly scale covering the pineal eye.

In several lizards and other reptiles, its position is indicated by a transparent area in one of the plates of the head and by an opening in the bones of the roof of the skull. In young reptiles and especially in a New Zealand lizard (hatteria), its identity with an eye is decidedly evident. Lens, retina, pigment, cornea are present (seen microscopically) as in some snails, but they finally degenerate more or less as the animal reaches maturity.

In the lizard, the pineal eye passes through the following stages of development: Formation of a hollow outgrowth from the roof of the third ventricle of the brain. This little sac elongates, changes its direction and becomes divided into a proximal and distal portion. The cells lining the distal part farthest from the brain become differentiated into the cell which will form the lens, and the cells which will form the retina. The distal parts become specialized; the lens, the retina and the stalk of the optic nerve are mapped out. The lens, the retina, and the optic nerve become fully formed. At this stage, the third eye has reached its limit of development. There is a well formed retina connected with the brain by a special optic nerve. The organ projects strongly from the surface of the head, but from this point, owing to the development of the cerebral hemispheres, degeneration begins. The nerve becomes broken and fatty, and pigmentary degeneration occurs in it. At the same time, the pineal eye having become useless or even harmful to the animal possessed of it, before the power of receiving perceptions of light has been lost and before the organ has been far reduced by the phylogenetic destruction, a veil of black pigment is formed over it, shutting it off from outer light. The nerve disappears completely before birth, its degenerate cells becoming lost in the mesoblastic skeletal tissue of that region. At the time of birth,

the whole eye is enclosed in a thick membrane which isolates it. The deposition of pigment has destroyed any functional activity in the lens and the retina, but these parts none the less retain traces of a complicated structure recalling their condition when functional.

In all vertebrates, including man, occurs a peculiar organ known as the pineal gland or eye. This pineal body was originally a central eye. The pineal body and its function have been mysteries to anatomists for years. In Addison's day as now among the theosophists, it was regarded as the seat of the soul. It is now known to be the remnant of an organ of sight, a third eye which looked out through the roof of the skull. The process of degeneration is clearly illustrated in Fig. 86. In the cyclops,

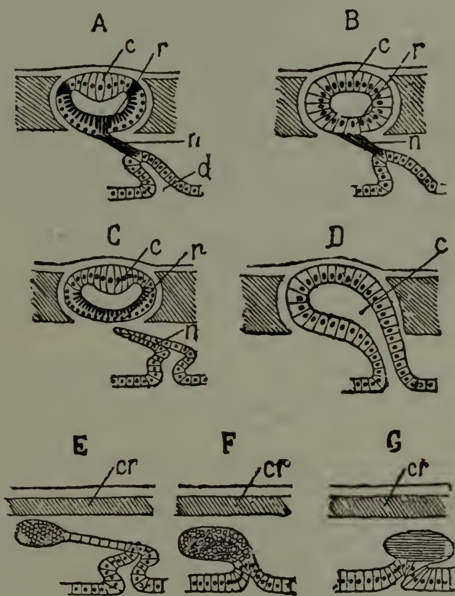


FIGURE 86

Diagram indicating the progressive evolution and the degeneration of the pineal eye (Baldwin Spencer). *A*, perfect pineal eye, as found in the slow worm before birth or in the adult sphenodon (Hatteria); *c*, lens; *r*, retina; *n*, optic nerve; *d*, divertialum of the thalamencephalon. *B*, pineal eye in the first stage of degeneration as it exists in the Chamaeleo and as it was in the slow worm before stage *A*. The lens (*c*) and the retina (*r*) are not differentiated. *C*, Pineal eye in the degenerate form found in Calotes and Lelodera; *C*, lens; *r*, retina; *n*, optic nerve in fatty degeneration. *D*, very degenerate pineal eye, as in Cyclodus and like the earliest stage in the slow worm; there is no differentiation of the divertialum from the thalamencephalon. *E*, *F*, *G*, other modes of degeneration of the pineal eye. The eye lies within the skull and there is no parietal foramen; or, cranial membranes. *E*, ceratophora. *F*, birds; *G*, mammals.

the state of things is reversed. The median eye, which ordinarily becomes the pineal body, here develops at the expense of the two eyes and the general nervous system.

The cyclops (Fig. 87) was born to a seventeen-year-old neuropathic

FIGURE 87

Human cyclops (original). The pineal eye which has taken the place of the paired eyes is seen in the center of the forehead. This is an arrest at the reptilian stage.

primipara, after a protracted labor. The child was living, but was killed by pressure on the funis. The mouth contained an ivory, tusk-like tooth at each corner. There was a mane-like hair around the neck.

Cyclopia is often associated with the absence of both the internal and external ear, and with synotis (joined ears).

In triophthalmic cases, the three eyes are usually separate, two occupying the usual position, while the third is situated as illustrated in the case cited. Ninety families of degenerates, averaging eleven children each, had five cases of cyclops.

Degeneracy, which affects so deeply the development of the eye, naturally tends to evince itself in other anomalous states in the organ. Excessive asymmetry of the body is one of the most noticeable of the stigmata of degeneracy. It is not astonishing to find that this asymmetry expresses itself both in the position as well as in the size and structure of the eye. Spiders and scorpions have a median eye spot associated with lateral eyes.

Somewhere along the line of phylogeny (probably at the sauropsidian stage), the pineal or central eye was lost for the benefit of the organism as a whole, while paired eyes took its place. In this connection, a marked

degeneracy or arrest in phylogeny is that of Fig. 88, the skull of a western desperado and murderer. The very large orbital cavities are an arrest in phylogeny at the lemurian stage and even lower carnivora type of mammal-

FIGURE 88

Skull showing excessive orbital cavities (Greves). The large orbital cavities, the superciliary ridges, the large mastoid processes indicate reversionary tendencies to the lower savage type.

ia. The large sockets are for the purpose of giving the eyes a wider range of vision. The large and prominent superior orbital arches are also a reversion to the anthropoid apes and early cave men for the purpose of protecting the eye from the sun, from limbs of trees and from blows of their enemies. The exceedingly large mastoid processes and occipital protuberances are also atavistic and are for the purpose of attachment of powerful muscles. With all these arrests in phylogeny, including a very small brain, such a person is more animal than human.

CERVICAL AND SHORT RIBS. In the embryo, man has been found to possess thirteen to fourteen pairs of ribs like the chimpanzee and gorilla. Adult man, however, has only twelve pairs. The "floating ribs" and their absence (in some instances) show this part of man's anatomy to be in a transitory state as these ribs are useless.

One unpleasant and at times dangerous reversion encountered by surgeons is that of the cervical ribs long lost by most mammals but which

return at the expense of the general organism to cause serious trouble and at times to endanger life.

Vermiform Appendix. Among the structures of reversionary type that have attracted most attention of late years is the appendix vermiformis. This, as elsewhere shown, is a rudimentary offshoot which is extremely variable. While this structure is very much in evidence, it is considered in this chapter because it is useless. Man retains this structure as a relic of having been at one time a vegetable feeder. In the koala (Australian native bear), a vegetable-feeding marsupial, it is more than thrice the size of the body. It is unusually large in the rabbit; in the horse, it has a caecum measuring on an average one meter in length and a capacity equal to thirty-five liters. In the carnivora, it has entirely vanished. In man, where it is sometimes absent and sometimes is as largely developed as in the orang, it is commonly from one half inch (Fig. 89 a) to twelve inches in length (Fig. 90) and about a third of an inch in

Figure 89
The vermiform appendix (original). The vermiform appendix is seen at (*a*) only one-half inch in length.

Figure 90
The vermiform appendix (original). The vermiform appendix is six inches in length.

diameter. The appendix is poorly supplied with blood, which predisposes it to attacks by microbes because of the absence of leucocytes to fight these and also because being, so to speak, a blind alley of the intestines, microbes find in it a suitable culture medium. The secretions of the appendix are very apt to decompose; hence a culture medium.

The extreme variability of this disappearing organ may be judged from the fact of their varying lengths, being anywhere from one half inch to eighteen inches. As it is best developed in degenerates, it constitutes in them one source of predisposition to death from blood poisoning or sudden shock. The location of this organ also tends to facilitate disease. In degenerates, it may be situated at any point upon the end of the big bowel, varying from two to three inches. This little bowel is worse than useless in man, being a source of serious danger. It is an instance of checked development of the same kind which causes the human liver to take on sauropsidian peculiarities. Man in this particular as well as the orang is lower than the carnivora, who have lost this worse than useless organ. Its tendency to disappearance in man indicates once more the truth that degeneracy of an organ is often, through the law of economy of growth, for the benefit of the organism as a whole. When the appendix is short, it is an advance in evolution; when long, it is an arrest in phylogeny.

Summary

There are many structures of the body which have become useless or have entirely disappeared. These structures are normal in adult lower vertebrates. They are as follows:—

Ear muscles.

Tail and tail muscles.

Great toe muscles.

Grasping power of infants.

Pineal eye and gland.

Cervical and short ribs.

Vermiform appendix.

Reversions to the lower vertebrate types have been reported many times by scientists and show an arrest in phylogeny.

The loss of these structures has been for man's benefit as a whole.

Chapter XIV

CONSTITUTIONAL DEGENERACIES DUE TO CHECK ACTION

Structures that are passing in Man's Present Evolution

THE structures passing in man's evolution and which are most important from a physiologic and pathologic viewpoint are the face, nose, jaws and teeth. In Chapter VII, "Development of Organs: The Head and Face," it was shown that the bones of the face, nose and jaws are partly derived from the skin and are dermal bones. A description of the phylogeny and ontogeny of these structures is there given. The degenerate changes taking place in brain development and arrest of development of the face, nose and jaws, due to an unstable nervous system, may be accounted for, in part, to the dermal bones. Brain development depends on the expansive power of the secondary skull formed by the dermal bones which may, in some instances, be degenerate, depending upon the early or late ossification of the sutures.

Early or late union of the sutures of the skull depends, to a great extent, as has been shown, upon brain development. If the brain develop small in bulk, as in the microcephalic idiot, the sutures unite early and the result with the bones themselves, are usually very thick and heavy, because of bone excess. On the other hand, if the brain develop large in bulk, as in the macrocephalic idiot, these sutures unite late or may not at all. Dermal bones are frequently necessary to fill the spaces (a wise provision of nature) Fig. 34. Here the skull is very thin from want of sufficient bone to properly cover the brain.

What is true of the cranium is likewise true of the bones of the face, jaws and teeth, since they are partly of dermal bones. The struggle for existence between the cranium and the bones of the face, jaws and teeth with the acquirement of normal nervous system is considerable, but when an unstable nervous system is to be reckoned with, the struggle between cranium on the one hand and the face, jaws and teeth on the other for bone material becomes fraught with difficulty.

That under favorable conditions, a struggle for existence between the bones of the face, jaws and teeth should take place is to be expected, since the two halves of the face develop independently of each other, and even each distinct bone has its own nerve supply.

In this chapter, it is my purpose to classify and try to show how degeneracies are brought about.

The Face

The study of the law of economy of growth revealed a struggle for existence between organs with interaction consequent on use and disuse of structures. Camper employed this law in his use of the ideal face of the Apollo Belvidere to illustrate the gradual retreat of the jaws from lower to higher types of face (Fig. 91).

FIGURE 91
Evolution of the face from the anthropoid ape (Camper). Showing arrest of the face and development of the brain and skull.

THE FACIAL ANGLE of Camper, Cuvier, Cloquets, Jacquarts, the Munich-Frankfort Angle and that of Topinard involves merely the bones of the face, not the inferior maxilla. Most authors dealing with prognathism and orthognathism include merely the superior maxilla in the concept. Stomatologic specialists must include the inferior maxilla in the outline, in order to determine what may or may not be required in improving the jaws and teeth. In my studies of the etiology of irregularities of the jaws and teeth, I have simply extended the facial line downward below the lower jaw (Fig. 92). This skull is representative of the Apollo Bevedere. An

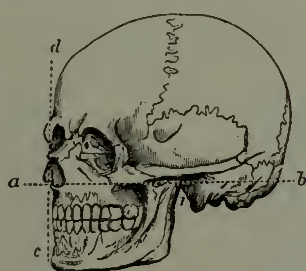


FIGURE 92
Face on the perpendicular line (original). This illustration shows the limit of the normal human face and jaws, in their evolution.

imaginary perpendicular line, dropped from the superciliary ridge below the lower jaw, decided whether the jaws be prognathous or orthognathous.

THE IDEAL FACE of Camper (last figure) is a norm, which shows where, in most cases, anatomic progress ceases and pathologic begins. At one stage

in the evolution of man the eyes, face, nose, jaws and teeth were most essential in obtaining food, and equally so in sexual selection.

It has been previously shown that when man proceeded to walk upon two legs instead of four and to use his hands for the purpose of feeding himself, the face and nose and long jaws were not required.

Owing to disuse, these structures have atrophied (degenerated). The brain and skull, on the other hand, needing this material, have appropriated it to their own uses. Wild animals, domesticated, show this change. The wild boar and domestic pig (Fig. 36) is one illustration; the bull dog another. This evolution in man is a normal healthy process. The structures of the face and nose develop partly from cartilage and partly from dermal bones. Calcification, therefore, does not go on uniformly in both structures. Cartilages are more susceptible to the influence of disease than dermal bones, because cartilages are slower in calcifying. They ossify slower than the dermal bones of the head. According to DeMoor, in their status as newer acquired structures, they are first to be affected by disease and to disappear. Changes in these structures take place along the line of least resistance, since the bones of the face and nose are the most variable in development. An unstable nervous system produces untoward effects upon these structures. Arrests in phylogeny and ontogeny, therefore, are to be expected.

In the development of the bones of the head, the order is as follows:—the chondrocranium, the first stage; the dermal bone function to protect the brain, the second stage; the ossification of the primordial chondrocranium, the third stage; the ossification of face, nose and jaws, the fourth stage.

As man developed, owing to brain increase, he acquired the power of obtaining and digesting food with less expenditure of physical strength. The jaws and teeth become less a factor in food-getting, hence their disuse and atrophy.

Up to this period of facial atrophy, the cavities of the nose were large enough for the purpose of breathing, the jaws large enough for the teeth, the teeth rarely decayed and interstitial gingivitis (owing to large, well-developed alveolar processes) seldom occurred.

While healthy recession is still progressing under the law of economy of growth, the perpendicular line remains the dividing line between the normal and abnormal.

Associated with antero-posterior arrest is lateral arrest of the face, which as a rule, is about as great as the antero-posterior. In such cases, protrusion (excessive development) of the nose and upper jaw often occurs. The lower jaw is usually arrested. The arrest begins at the upper border of the nasal bones at their junction with the frontal, extending downward

to a point midway between the angle of the lower jaw and the symphysis of the chin.

This phase of evolution underlies all pathology of the face, as well as of the nose, jaws, alveolar processes and teeth. The illustrations supplementing those of Camper portray this reverse phase where symmetry of the body as a whole is sacrificed to changes in the nose, jaws, alveolar processes and teeth, in order to preserve cerebral gains.

The accompanying illustration (Fig. 93) taken from photographs of

FIGURE 93
Evolution and degeneration of the face (original). The process of evolution of the human face is still going on. This illustration shows clearly the degeneration of the structure of the face for the benefit of the brain which is evolving higher in man's evolution.

patients, accurately portrays arrests of the face for the benefit of the brain. The gradual recession of the face and the forward development of the brain is a gradual continuation of Fig. 91, in the line of evolution. From the relation of this face degeneration, nearly all diseases of the nose, jaws, alveolar processes and teeth result. In many cases, reverse evolution progresses still further, until owing to an unbalanced nervous system and free movements of the lower jaw, atavism intervenes. Illustrations 8 and

FIGURE 94
Phylogenic arrest of the face (original). Here is seen an atavistic tendency in which the brain is undeveloped but the face, jaws and teeth are a return to the lower negro type of face.

FIGURE 95
Prognathous skull (Greves). Showing type of previous figure.

9 (Fig. 93) exhibit a greater exaggeration of the lower jaw, that is, a return to the anthropoid and lower negro types.

In the study of the evolution of the face, five types are to be considered:

FIRST: AN ARREST OF THE FACE AND HEAD IN ITS PHYLOGENY. Here the face extends beyond the perpendicular line (prognathism) and the forehead recedes inside the line and is atavistic (Fig. 94). The teeth articulate normally.

Fig. 95 is that of a skull showing more clearly the outline of this type of face. The jaws, face and nose are outside the perpendicular line. The forehead recedes inside the line. The jaws are large, well developed, with a width of two and one-fourth inches. The thirty-two teeth are large, well developed, with bell shaped crowns and with little or no decay. Tooth

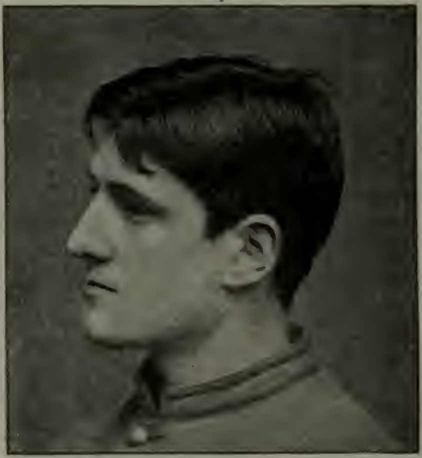


FIGURE 96
Ontogenic antero posterior arrest of the face (original).

FIGURE 97
Skull showing ontogenic arrest of the face (Greves). Skull showing type of previous figure.

structure in both enamel and dentine is fine grained and dense. The teeth are well set in the jaws, with plenty of alveolar process between and about their roots, giving sufficient nourishment to the surrounding structure, with little tendency to interstitial gingivitis. The vault is medium in height without irregularities of the teeth. Such people masticate their food and use the jaws with much more vigor and pleasure than those who possess smaller jaws. Their jaws are atavistic and resemble the lower negro type. The mentality of this class varies from the lowest form of idiocy, with lemurian brain capacity, to the highest and most intelligent individuals. The forms of mentality have been discussed in Chapter IX.

Second: The antero-posterior arrest in which the face is arrested in

its ontogeny inside of the perpendicular line, including the upper jaw. The lower jaw is normal or it may be arrested (Fig. 96).

Fig. 97 is that of a skull which illustrates the type of face described on or inside the perpendicular line. The jaws, as a rule measure from 1.70 to 2.25 inches across. There are rarely thirty-two teeth; one or all four of the third molars are wanting. There are nearly always irregularities of the teeth, decay and interstitial gingivitis. Mastication of food is poorly performed. The mentality of this class varies from the lower to the highest brain development. The figures are graded according to mentality.

Third: There is a lateral arrest in the ontogeny of the face, beginning at the nasal bones and extending downward and backward to a point midway between the symphysis and the angle of the jaw. There may be an arrest antero-posteriorly, or the face may extend beyond the perpendicular line. The lower jaw may be outside, on, or inside the line. The teeth may or may not be normal in occlusion (Fig. 98).

Fig. 99 is a skull showing the type of face described in this classifica-

FIGURE 98
Ontogenic lateral arrest of the face (original).

FIGURE 99
Skull showing type of previous figure (Greves).

tion. The narrow, contracted bones of the face are well outlined. The jaws are always too small to contain thirty-two teeth, in normal position. If they be present, they are irregularly placed, or the third molars are unerupted. More frequently one or all of the third molars are absent. Not infrequently some of the other teeth are lacking. The alveolar processes are long and thin with marked interstitial gingivitis. Decay of the teeth is very common.

Fourth: The face and upper jaw may become arrested in its phylogeny and remain outside the perpendicular line, and the lower jaw remain on the line or arrested in its ontogeny inside the line. The teeth on the upper jaw protrude beyond the lower (Fig. 100).

Fig. 101 shows the bones of the face in this class of deformities. There is always an excessively developed upper jaw with a normal or arrested lower jaw. In correcting such a deformity, it is very essential that the operator should satisfy himself in regard to the nature of this deformity before undertaking surgical procedure. Sometimes the body of the lower jaw is arrested in development and sometimes the rami. Again the lower jaw may be normal.

FIGURE 100
Phylogenic arrest of the face and upper jaw (Lee Wallace Dean).

FIGURE 101
Showing type of previous figure (Greves).

Fifth: The face and upper jaw may become arrested in ontogeny and remain inside the perpendicular line, while the lower jaw, on account of its mobility, may become arrested in its phylogeny, extending beyond the perpendicular line. The teeth upon the lower jaw protrude beyond the upper (Fig. 102). All other forms are modifications of these five. They may be more or less intense.

Fig. 103 is a skull demonstrating this class of deformities. In this illustration, the body of the jaw has become over-developed. In other patients, the rami may be excessively developed and the body remain normal in size.

This general consideration of changes in face development leads to discussion of individual degeneracies. Taking Fig. 91 as our guide,

the struggle for existence between the brain on the one hand and the face on the other is most striking. A consideration of evolutionary changes in phylogeny reveals that development began without a brain and the head was on a line with the body, like fish and reptile, and was nearly all face and jaws; it is easily understood, then, the struggle that has taken place between the brain, face and jaws for supremacy through the ages. Many animal species with advanced brain development and smaller jaws have

FIGURE 102
Phylogenic arrest of the lower jaw (original).

FIGURE 103
Skull showing type of previous figure (Greves).

strayed from the direct path of evolution, while man has persisted in the straight and narrow way until the brain has developed and has become master over the face.

Under each type, there is as great a contrast in mental development as there is in face and jaw deformities.

In this struggle for existence not infrequently, owing to disease in the parent or child, atavisms occur. The brain remains undeveloped at periods of stress and resembles pre-vertebrate types, like the cyclops (the cyclops have already been described and illustrated); vertebrate types like fish, reptile, bird, lower mammal, lemur and anthropoid ape.

First Classification.

Fig. 104 is the head of an idiot. The struggle here has been reversed; the face, jaws, teeth and ears have gained at the expense of the brain, resulting in a most marked atavism. The atavistic brain of this girl (Fig.

58) is an arrest in phylogeny and at the lemurian stage. The cerebellum is exposed and the convolutions are few. The atavistic jaws are large as

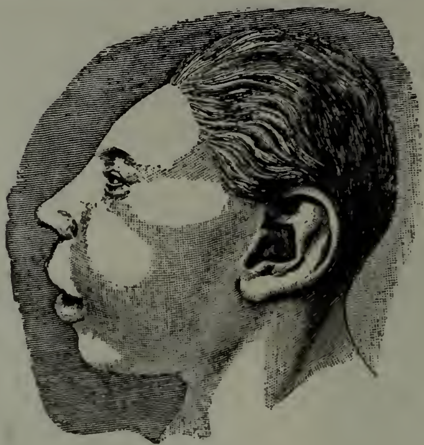


FIGURE 104
Head of an idiot girl (Ziegler). Showing sacrifice of brain and skull for the benefit of the face, jaws and ears.

well as the teeth, free from decay in normal people, but in such a patient, decay is very active due to an unstable nervous system and want of personal cleanliness.

Fig. 105 illustrates the head of a knife-grinder (L'ARROTINO) of Asia Minor, from a famous marble in the Uffizi Galleria, Florence. The idiotic

FIGURE 105
Head of a knife grinder (L'Arrotino).

expression on the face is pronounced. He has a receding (atavistic) forehead with protruding (atavistic) face and jaws. The fact that he has an occupation shows that he possesses a brain a little in advance of the idiot in the previous illustration. This man comes under the pauper class.

Fig. 106 is that of a thirty-six-year-old habitual criminal. He is a horse thief. He has been in the penitentiary most of the time for twenty years. The jaws measure two and one-half inches in width and have

FIGURE 106
Habitual criminal, horsethief (original).

thirty-two well developed sound teeth. The brain development is higher than in the two preceding illustrations.

Fig. 107 is that of a Russian harlot. The anterior part of the head

FIGURE 107
Russian harlot (original).

slopes backward denoting lack of frontal brain development. The jaws protrude beyond the perpendicular line. The jaws have large well developed teeth, without caries.

Fig. 108 is that of a thirty-two-year-old university graduate who gained considerable notice as an athlete during his college career. Since graduation his highest ambition is a professional masseur. He has no

office but goes to his patrons. His fees are exorbitant and he believes his services are worth more than he charges. Only a very few wealthy people

FIGURE 108
A college graduate, and extreme egotist (original).

are his patrons. He spends all his money upon dress and borrows when occasion requires. His jaws are large and have thirty-two well developed teeth. He is an extreme egotist.

Fig. 109 is that of a well-known actress. This head shows the extreme in mentality. The jaws protrude beyond the perpendicular line.

FIGURE 109
A brilliant actress (original). Although the type of head and face is similar to the class yet in this case the gray matter and cell development predominates.

It will be seen that atavism in brain and jaws (Fig. 95) causes these structures to descend the scale of evolution (Fig. 91). The distance to which the individual may travel will depend upon the depth of the degeneracy.

Second Classification

In the second classification, the face and jaws are on or inside the perpendicular line in normal healthy evolution. This, in a general way, is an advance in facial evolution, but, however, is not always the case, since neurasthenia, in parent or child or both, may cause arrest of development in brain and face ontogeny.

Fig. 110 is that of an insane person. There is marked arrest of the face, including the eyes, which are small and sunken. The nose is markedly

FIGURE 110
An insane person (original).

FIGURE 111
A one-sided genius (original).

deformed and curved to the left. There is nasal stenosis with deflected septum; hypertrophy of middle turbinates on the left and arrested middle turbinates on the right side. The right eye and ear are higher than the left. There is an arrest of the upper jaw with a V dental arch and vault. Teeth are badly decayed. The lower jaw is normal. The brain of this man is not unlike that of Fig. 59, in which only a few convolutions are seen.

Fig. 111 represents the face of a one-sided genius, a mechanic who has produced a number of useful inventions. His hobby is perpetual motion. There are times when he has complete loss of memory. On one of these occasions he demanded his salary from the wife of the owner of the shop in which he was employed. Because she refused, he struck her on the head. For this offense he was sent to the hospital for the criminal insane. The eyes are small and sunken. There is nasal stenosis with marked arrest of the face and upper jaw, and a partial V-shaped dental arch. The ears stand out from the head. The lower jaw is normal.

Fig. 112 is a twenty-two-year-old man with lateral arrest of the nose, face and upper jaw. He has harelip and cleft palate. The right side of his face, including the eye and ear, is higher than the left. The nose is

long and deflected to the right. The right ear is fairly normal while the left is badly deformed. The teeth are irregular. The lower jaw is normal.

FIGURE 112
A degenerate face but fairly well developed brain (original).

FIGURE 113
A kleptomaniac (original).

The young man sold newspapers. He assaulted the man for whom he worked and was sent to the reformatory.

Fig. 113 is a twenty-nine-year-old clegyman who gained considerable public attention from his sermons. He has a mania for visiting book stores and appropriating books for his own use without paying for them. There is marked arrest of the face, nose and both jaws. The right side of the face, eye and ear are higher than the left. The upper border of the left ear is arrested. He has a high vault with deformed dental arches. There is quite an arrest of the lower jaw.

FIGURE 114
A criminal banker (original).

FIGURE 115
A brilliant lawyer (original).

Fig. 114 is that of a forty-eight-year-old banker. He was sent to the penitentiary on an indeterminate sentence for swindling his patrons by

selling first mortgages on the same piece of property nine times, and also for other similar crimes. Here there is marked arrest of the face, eyes, upper jaw, with normal lower jaw. This man formerly had adenoids, hypertrophied turbinates and deflected septum. He also has a V dental arch and high vault. The ears are large and stand out from the head. He is flat footed and toes in.

Fig. 115 represents one of the brainest internaitonal lawyers. While the type of face is not unlike that of the others in this class, the brain development is similar to that of the great mathematician Gauss.

Third Classification

In the third classification, the arrest of development is a lateral arrest extending from the nasal bones, downward and backward, midway between the symphysis and the angle of the lower jaw. The face is narrow and is called a hatchet face. The nose is long and thin. The lower jaw is usually arrested in this class of cases.

Fig. 116 is the face of an insane criminal. In this patient, the effects of neurasthenia in the parents or disease in the child has left its imprint

FIGURE 116
An insane criminal (original).

FIGURE 117
A ward politician, an habitual liar (original).

most forcibly upon the brain and face. To the observing physician, there could be no mistake in locating excesses and arrests of development in face, eyes, nose, mouth, teeth and chin. We should expect to find irregularities of the dental arches, mouth-breathing, hypertrophied tonsils, adenoids, hypertrophy of the nasal bones, turbinates, vomer, with hypertrophy of the mucous membrane. The brain arrest might resemble any one of the illustrations shown in Chapter IX.

Fig. 117 is that of a twenty-four-year-old man who not only has the

lateral arrest of the face but has a very sloping forehead as well as arrest of the chin. He is a ward politician of a low order and an habitual liar. He has served time in the state reformatory. A description of the deformities of this face are not unlike those of the previous character. He has a marked saddle dental arch with high vault, nasal stenosis with the usual hypertrophies and atrophies.

Fig. 118 is a thirty-five-year-old criminal. He has committed two murders, one in the west, the other in the east. There is a marked lateral

Figure 118
A murderer (original).

Figure 119
An actor (original).

arrest of the face with deformed jaws and V dental arch. This subject has adenoids, a deflected septum with hypertrophied turbinates. The right side of the face, eye and ear are higher than the left. Eyes are small and sunken.

Figure 120
A "smart" business man (original).

Figure 121
An "eccentric" business man (original).

Fig. 119 is the face of an English actor of no mean ability. He has

the hatchet variety of face. He has marked dental irregularities and high vault.

Fig. 120 is an illustration of a "smart" business man, a manufacturer. He has attained great wealth by taking advantage of people in business. He possesses the usual deformities of face, nose, jaws and teeth.

Fig. 121 is the face of a thirty-two-year-old business man who is eccentric in a marked degree. He has an unusual lateral arrest of the face, the jaws measure one inch from the buccal surfaces of the first molars, a very pronounced saddle dental arch, high vault and irregular teeth. He has had his nose operated upon for adenoids, spurs and other hypertrophies.

Fourth Classification

In this class the deformities are quite prominent, the dental articulation is so poor that proper mastication is impossible.

Fig. 122 is the picture of a forty-eight-year-old business man. He is only fairly intelligent. The shape of his head would indicate that. He

FIGURE 122
"Fairly intelligent" business man (original).

is not over and above successful in his business. He has a large nose, ears and upper jaw, with a decided lateral arrest of the face and lower jaw. The teeth of the upper jaw extend beyond the lower .60 of an inch. The usual hypertrophy of tonsils, adenoids and turbinates are noticed. This class of deformities is also seen in the different walks of life, but more especially is this the case in the more marked forms of degeneracy. We

rarely find this type of face among the more intelligent class of people. So marked an impression is made upon the child by disease in the parents that the brain feels the impress.

Fifth Classification

Of all the facial degeneracies, none are so pronounced as those which come under this classification. From a pathologic viewpoint, it demonstrates most clearly the action of an unstable nervous system upon development of bony structures.

In this class of cases there is marked ontogenetic arrest of the face nose and upper jaw, while there is excessive phylogenetic development of of the lower jaw. The upper jaw, being a fixed bone, does not receive as much nourishment as the lower jaw. The lower jaw being movable, it is more liable to become excessively developed at the expense of the upper jaw.

Fig. 123 shows such a condition. The face, including the nose and upper jaw, has become arrested while the lower jaw is excessively developed.

FIGURE 123
A successful lawyer (original).

In this patient, the lower teeth protrude .30 of an inch beyond the upper. I have in my practice a thirty-eight-year-old lawyer of no mean ability, a university graduate and also a graduate of a law school, with a similar facial and jaw deformity.

INTELLECTUAL RELATIONSHIPS. A classification of facial types and their relation to intellectuality has been clearly shown. There is not nor can there be a criminal type of face as claimed by some scientists. All that can be said in this relation is there is a degenerate type of face. The mentality may vary from the lowest idiot to the most intellectual. Between the two extremes all the views occur. These facial types may be

found in all nationalities. Each nationality has its peculiar type of face. All studies must be considered from the two standard forms of heads, the brachycephalic of the German and the dolichocephalic of the negro. In the blending of nationalities and the intermixture of races, the tendency of these two extremes in mingling is to produce a mesaticephalic head. What would be considered normal in one nationality would be a degeneracy in another. In the study of degenerate facial types the normal native type must always be a norm from which to study departures.

National Development. It is interesting to study some of the basic principles in two or three nationalities to note the progress of evolution in the facial angle. To start with the negro type (Fig. 91) including all the heads in this figure and those of Fig. 93 we have the types of all the different races from the ancients to modern times. A close study of these illustrations reveals a firm foundation to determine racial types by the facial angle. A comparison of the two extremes, from the lowest American negro types to the highest educated people of the oldest countries of the world, may be of value.

An examination of the lowest negro type in Mississippi was made by Dr. William Ernest Walker of New Orleans. His examinations of three hundred and fifty-seven, showed the facial angle protruded beyond the perpendicular line in ninety-seven and five tenths per cent of jaws, while two and five tenths per cent of jaws examined were on the line. An examination by Dr. Arthur R. Dray of six hundred and eighty-six negroes in Philadelphia, eighty-three and fifty-seven one hundredths were found outside the perpendicular line; fifteen and ninety-five one hundredths on the line and forty-two one hundredths inside the line. An examination of one thousand and eighty-five in Chicago, fifty-one and six one hundredths per cent protruded; thirty-one and eight tenths were on the line and sixteen and six tenths per cent were inside the line. An examination of one thousand negroes in Boston by Dr. Eugene F. O'Neill showed forty-five and four tenths per cent outside the line; thirty-nine and five tenths per cent on the line and fifteen and one tenth per cent inside the line. It will be seen, therefore, that in Northern and in old negro families, from race admixture and environment, there is less protrusion and more recession than in the Southern pure negroes. Arrest of the bones of the face is as common in old negro families in the North as among the Caucasic races.

An examination of ten thousand people in the streets of London on the other hand revealed the fact that in only four and thirteen one hundredths per cent of people examined did the jaws extend outside the perpendicular line; twelve and eighty-seven one hundredths per cent on the line, and eighty-three per cent inside the line. In an examination of three thousand English school children (about ten years of age) ninety-three per

cent possessed jaws inside the perpendicular line; six per cent on the line and one per cent outside the line. An examination of eight thousand people in Boston showed six per cent of jaws extending beyond the perpendicular line; fourteen per cent on the line and eighty per cent inside the line.

In comparing the evolution of the Aryan race with those of the negro, it will be seen that the negro in this country has undergone, in two hundred and fifty years, as rapid facial change as has taken place in the Aryan races in thousands of years. This is interesting, since we can more readily understand the causes which produce these changes in the facial angle and study them in the negro race.

Ancient and Modern Characteristics. In comparing the lateral measurements of the jaws (Fig. 155) of modern races with ancient skulls and ancient races, a marked difference in size is noticed. A few of these measurements will be given here for comparison. Examinations of ancient skulls made by the late Dr. Mummery, in 1860, of ancient British skulls measured minimum 2.12 inches, maximum 2.62 inches, with an average of 2.37 inches. The modern English jaws measure minimum 1.88 inches, maximum 2.44 inches, with an average of 2.19 inches. The jaws of people living in America measure minimum 1.75 inches, maximum 2.52 inches, with an average of 2.14 inches. The difference between the ancient Roman soldiers and modern Romans is the same as that of the English. The lateral measurements of the pure negro as found in Mississippi are minimum 2.25 inches, maximum 2.75 inches, with an average of 2.51 inches. The lateral diameter of modern negroes varies considerably owing to neurasthenia in the parents and disease in the child. Some jaws measure as low as 1.75 inches. The jaws of modern negroes residing in Boston for many generations are not unlike those of the native whites.

Dr. Charles Ward says a "point in which the jaws of aboriginal tribes, are, as a rule, superior to those of civilized races is in the proportions of the horizontal ramus. As pointed out by Harrison Allen, the alveolar and inferior border of the jaw tend to parallelism in savages, while in civilized races the symphysial height is usually greater than the height in the vicinity of the molars. This may be due to gradual degeneration of the platysma myoides muscle. Of the significance of the "antegonium" or "pregonium" of the same author I am uncertain, but incline to the belief that it is a "stigma of degeneration." Finally, an as yet incompleted study of the relative proportion of jaw to skull has convinced me that the jaws of savages are not only proportionately but actually heavier than our own, and that the "cranio-mandibular index," as I term it, which is the ratio between the weight of jaw and weight of cranium, rises steadily as we descend from semi-civilized to barbarous and savage tribes.

"Thus, while the white males examined gave an index (proportion of jaw to skull) of 11.8, the male Australians presented an index of 15.4.

"Absolute size of the lower jaw is greater in savages: Of nine aborigines, including seven North American Indians, one African and one American negro, six Malays and five Australians, all with beautifully perfect teeth, the mean weight of the jaw was 102.4 grams. Of eighteen white males the mean weight of the jaw was only 83.4 grams. Yet the weight of the skull was nearly alike in both classes, being 690.9 grams for the aborigines as against 680.5 for the whites. The weight of the lower jaw compared with that of the cranium, or the Cranio-Mandibular Index is 15.6 for aboriginal men as against 12.16 for white men. It is 46.2 for the anthropoid apes, our nearest living relatives among mammals."

The change in the two extremes of heads, the brachycephalic and the dolichocephalic to the mesaticephalic also produces change in the shape of jaws in like manner. Instead of the large round jaw of the brachycephalic and the long narrow jaw of the dolichocephalic, a medium size jaw development also follows.

Summary

In man's homogenetic course, the face, nose and jaws are growing smaller and the teeth are being lost through disuse of structures.

In studying the facial angle, the lower jaw should be included in the concept. This is very necessary in the correction of irregularities of the teeth, since an imaginary line extending from the superciliary ridge below the lower jaw determines whether the jaws be protruding or not. Many noted scientists have lost sight of this and have made no mention of it in their writings.

Owing to disuse, the facial structures are degenerating, while the brain and skull are increasing from the material which would ordinarily go to these structures.

In the growth of the bones of the head, there is first, the chondrocranium or primary skull; second, the protection of the brain by the dermal bones; third, primary skull ossification; fourth, face, nose and jaw ossification.

Before man began to obtain and digest his food with less physical exertion, the jaws were large enough to contain thirty-two well developed teeth with little decay and no interstitial gingivitis.

At the present time, on account of arrest of the bones of the face and disuse, the jaws have grown smaller, are inside the perpendicular line and cannot contain thirty-two well developed teeth, decay is prevalent and interstitial gingivitis is common. These conditions are the foundation of

all pathology of the face, nose, alveolar process and teeth. In order to make this clearer, I have added to Camper's illustrations, profiles of patients, typifying facial atrophy for the brain's benefit.

To obtain a clear idea of facial development, five types must be borne in mind. First, the protrusion of the jaws beyond the perpendicular line and recession of the forehead inside the line. Second, the recession of the jaws inside the perpendicular line. Third, lateral arrest of the face. Fourth, the face and upper jaw protrude beyond the perpendicular line while the lower jaw is inside the line. Fifth, the face and upper jaw remain inside the perpendicular line and the lower jaw protrudes beyond the line.

Monstrosities sometimes occur resembling prevertebrates and vertebrates in connection with these face malformations, due to a lack of brain growth at periods of stress. The mental conditions as well as other deformities are discussed under each illustration.

Many investigators claim there is a criminal type of face but a study of facial deformities precludes this statement. There is, however, what may be called a degenerate face.

Brachycephaly, or round head, and dolichocephaly, or long head, are the two classifications from which to study head change. Owing to race intermixture, environment, change of climate, soil and food the tendency is toward mesaticephaly or medium head. The change in skull type has produced a similar change in the jaws. The greatest change in head and face type is to be found in the evolution of the American negro. According to Charles Ward, the lower jaw of savages is greater in size and weight than in civilized races.

Chapter XV

THE NOSE

The External Nose—Arrests in Development in its Phylogeny

THE external nose, in its phylogeny, passes from the snout stage of the lower vertebrates to the aquiline type of the genus *nasalis* (proboscis monkeys) (Fig. 124) and man. This change takes place

Figure 124

Genus nasalis or proboscis monkey (Library of Natural History, Vol. 1, Sec. 1). This illustration shows the period in phylogenic development when the nose is substituted for the snout.

in the evolution of the face backwards. The face shortening in man's upright position and from disuse of the nose and face, on account of their higher functions (the senses), causes these structures to degenerate for the benefit of the organism as a whole.

The nose in its phylogeny becomes more complicated, since it must be adjusted to the general sense of smell in man's upright position. The dog can smell footprints and determine sex, but it only specializes and does not generalize as does man.

These changes take place from the anthropoid ape type. The human nose is prefigured in the genus *nasalis.* There is, in this change, an increased use of bone for protection of sense organs, like that which occurs in the skull. At times, the bone increase in the nose occurs at the expense of the bone increase in the skull, resulting in idiots whose nose type is low or high but whose skull type is ape-like.

Fig. 125 is another example of the struggle for existence between organs. Here again are demonstrated potentialities which pass through periods of stress when the newer type (the brain) competes with organs already existing (the face and jaws); the nasal excess of material takes

the path of least resistance and is an arrest in phylogeny at the snout period. The face, nose and jaws have gained at the expense of the brain. This child was born of healthy half-caste African parents. There is little, if any, brain development, while, on the other hand, the face, nose and jaws are well developed. There is an arrest in ontogeny of the superior maxil-

FIGURE 125
Phylogenic arrest at the snout period of the face, nose and jaws (Gould and Pyle). The face and jaws have developed at the expense of the brain and skull.

FIGURE 126
Phylogenic arrest at the snout period (Gould and Pyle.) The head and face and jaws compare favorably with the following figure.

lary bone, causing cleft palate and harelip. The eyes are without lids, lashes or brows. The second and third fingers of both hands are webbed for the whole length. The right foot lacks the distal phalanx of the great toe, and the left foot is clubbed and drawn inward. This is typically atavistic of the sauropsidian character so far as concerns brain and hand development, and of the anthropoid ape character so far as the feet are concerned. The nose is of the primitive snout-like type.

Fig. 126 also represents an individual with excessive development of the face, nose and jaws at the expense of the brain. Here again the snout-like nose is associated with a large lip resembling the lower vertebrates.

These two illustrations show an arrest in phylogeny of the face and nose below the genus *nasalis* type (Fig. 127).

FIGURE 127
Head of an anthropoid ape (original).

FIGURE 128
An Aztec idiot (Gould and Pyle). Here the brain and the skull have become arrested in development for the benefit of the face, nose and jaws.

Fig. 128 is that of the "Aztec man," exhibited for many years in side shows. This illustrates the increase in the face, nose and jaws at the expense of bone increase in the skull, resulting in the excessive development of the nose above the genus *nasalis*—a marked arrest in phylogeny at the ape stage.

FIGURE 129
Excessive nose development in an idiot (Gould and Pyle). The nose has gained at the expense of the brain and skull.

"Early in the last century a man named Thomas Wedders, with a nose seven and one half inches long, was exhibited throughout Yorkshire, England. This man expired as he had lived, in a condition of mind best described as the most abject idiocy. The accompanying illustration (Fig. 129) is taken from an old print and is supposed to be a true likeness of this unfortunate individual." Unlike the last illustration, the increase is in the nose alone and occurs at the expense of bone increase in the skull. This nose is also an excessive development in the evolution of man above the genus *nasalis*.

In the evolution of the face, the nose has assumed certain types quite unlike each other; for example, the Greek, the Roman and the Hebrew are normal so long as they retain the type. Deviations from these types, however, are degenerative. Race admixture, together with changes in environment and disease, has caused the nose to assume different shapes. Roman celebrities who had long, large noses are Pompilius Numa, Plutarch, Lycurgus and Solon; and all the kings of Italy except Tarquin the Superb. Arrests in phylogeny of the nose, at the genus *nasalis* type, are frequently observed.

External Nose—Arrest in Development in its Ontogeny.

The nose in its ontogeny frequently becomes arrested as a result of disease in the parent or child. This arrest may take place at any period from the beginning of intrauterine formation, through any of the periods of stress to maturity. The most marked cases are those of congenital syphilis. The absence of the external nose is rare. Maisonneuve observed one individual in whom, in place of a nasal appendix, there was a plane surface perforated by two small openings.

Fig. 130 is that of a thirty-seven-year-old, well educated school teacher of nervous temperament. There is arrest of the nasal bones as well as

FIGURE 130

Ontogenic arrest of the nose (original). The illustration of exceedingly bright school teacher.

the nasal cavity. The face and jaws are well developed. She is a mouth-breather. The chest is undeveloped.

Fig. 131 represents a man with marked arrest of the face as well as the nose. This arrest must have taken place very early in childhood.

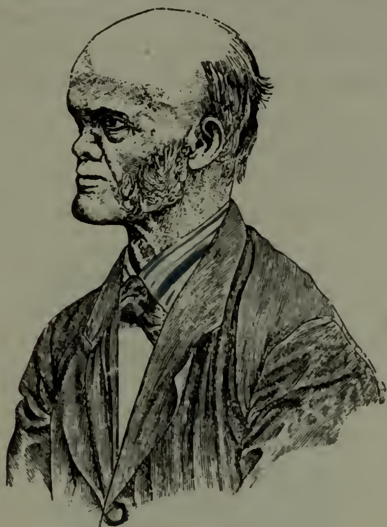


FIGURE 131
Ontogenic arrest of the nose and face (original). The face is arrested for the benefit of the brain and the skull.

Many noted men have had extremely short noses. The following examples may be mentioned: The Duc de Guise, the Dauphin d'Auvergne and William of Orange, celebrated in the romances of chivalry.

A general view of the nose often reveals a want of harmony in its general outline. The nasal bones are arrested in development and the tip is turned up, from a normal or excessively developed cartilage. Another very marked deformity is that in which nasal bone and cartilage are excessively developed. The bone takes one direction and the cartilage another, producing a double nose. This condition is very common among Hebrews. Other nationalities may also have nasal organs with material enough for two fair-sized noses, demonstrating a tendency toward least resistance in development. In a majority of such cases, total collapse of the walls of the nose and, frequently, mouthbreathing results.

In over 2,000 measurements of the nasal bones, the shortest was found to be .40, the longest 1.65 of an inch in length. Even the bones without the cartilage would make a fair-sized nose. These bones take different angles. Those which are the largest take the greatest angle. A species of deformity, more common than generally supposed, is that in

which the nose is deflected to the right or left. This deformity, however, is often so great that it produces a marked asymmetry of the face, and just as often it is so slight as to be unnoticed by the average observer. It is carried to the right or left by unbalance of development in the cartilaginous structures at a period when only the soft tissues are involved. When the nose bones are deformed, quite another condition results.

Marked deflection in as well as other deformities of the nose, are not observed in early life. As the face develops the deformity becomes more prominent and at puberty is well defined, although it does not reach its full extent until twenty-five or thirty years. In most instances, the two lateral halves of the face are asymmetric, as well as the nasal bones. The bones of the nose develop upon one side and deflect the lower border to the opposite side, where the bones are undeveloped. This has a tendency to deflect the cartilaginous septum in the same direction, which, in turn, exaggerates the deformity. Noses in neurotics and degenerates may be deflected nearly forty-five degrees from a normal position. These marked deflections have been charged to intrauterine injury or at birth. As the bones of the nose are undeveloped at birth and as marked deflection is not observed until later in life, such a theory fails to fit the case. An excess or arrest of development of the bones of the face is more likely the cause of such stigmata.

The Internal Nose—Arrests in Phylogeny of the Nasal Cavity

In the chapter upon the face, it was shown there were five types. The first three of these (in which the nose and upper jaw are involved) are of interest here. The first type comprises those faces in which the nose and upper jaw are well developed and are outside the perpendicular line; second, those in which there is an antero-posterior arrest and are inside the perpendicular line; third, those in which there is a lateral arrest of the nose and face. The nose and upper jaw may be outside the perpendicular line, on or inside the line. The shape and position of the lower jaw does not concern us in regard to degeneration of the nose, except that arrests and excessive development of this bone assist in the diagnosis of the depth of the degeneration affecting the structures.

Of the bones of the head, those in the face, nose and jaw region are the most affected by degeneracy. The severity of the arrest depends upon the depth of the degeneracy. These bones are most affected, first, because of their position just below the cranium; second, because of their shape, position and size, all being thin with cavities between; third, because they are cartilaginous, derived from the chondrocranium, and are slow in calcifying; fourth, because they are fixed bones; fifth, because the arrest of the bones of the face takes place at the early periods of stress.

The cranium above, on the other hand, being derived from dermal bones is a newer acquirement of the body. It covers the brain which is evolving higher in development and is more persistent. The lower jaw develops partly from Meckel's cartilage and partly from the chondrocranium, and being a movable structure, is easily influenced by an unstable nervous system. It may become excessively developed or arrested, but is more likely to develop normally than the upper jaw because of its independence and mobility.

The first type of face (Fig. 94) in which the nose and upper jaw are well developed and extend beyond the perpendicular line are seen in those patients in which there is plenty of room (Fig. 132) in the nasal cavities

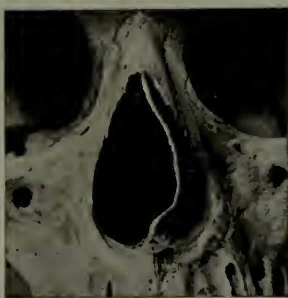


FIGURE 132
Arrest in phylogeny of the internal nose (original). The septum is deflected to the left owing to an excessively developed right inferior turbinal bone.

for the passage of the full amount of air. If hypertrophy, spurs and deformities occur, they are of such a nature that they do not interfere to any extent with nasal breathing. There are seldom adenoids. The upper jaw is well developed. Teeth are all in normal position. The vault is normal in development. These patients are not mouthbreathers.

Arrests in Ontogeny of the Nasal Cavity

The second class of patients (Fig. 96) possess an antero-posterior arrest of the nose and upper jaw, in which the face is sunken. In these patients, there is always stenosis of the nasal cavity (Fig. 133) and the upper jaw is so small there is not room for sixteen teeth. The teeth are more or less crowded and out of shape. A V or saddle-shaped arch or their modifications are usually seen.

The third class (Fig. 98) in which there is a lateral arrest of the nose, face and jaws have the same pathologic conditions as found in the nose

and jaws of the second classification. In this class of cases, however, the external nose is long and thin. The nostrils are almost closed.

The marked distinction between the first class of patients and the second and third classes is, that in the first class the bones of the face and

FIGURE 133
Nasal stenosis (original). The septum is deflected to the right owing to an hypertophied middle turbinate.

upper jaw are well developed, giving plenty of room (even with a fair amount of hypertrophy and deformity) in the nasal cavity for the inhalation of sufficient air to aerate the blood. On the other hand, owing to an unstable nervous system in the parents, or disease in the child, arrests of development of the bones of the face in the second and third classes have occurred, causing an arrest of the nasal cavity, preventing the normal amount of air from entering the nose. In some patients, the hypertrophies, deformities and adenoids completely close the cavities. It is in the last two classifications that mouthbreathing occurs.

An examination of the skulls of Peruvians, stone-grave Indians, mound-builders, cliff-dwellers, Hawaiians, etc., demonstrated that the width of the external nasal cavity varied considerably. In two thousand measurements, the greatest width was 1.25 inches. The smallest width was .75 inches. The length from the nasal spine to the edge of the nasal bones was, greatest length, 1.54 and the smallest 1.20. In neurotics and degenerates, when arrest of development of the face and nose has taken place, the width measured .50 to .60 of an inch and the length .80 to .90.

Arrest and Excessive Development of the Turbinals

The bones of the nose are both cartilaginous and dermal in their development. According to Minot, "The median ethmoidal plate sends outgrowing laminae of cartilage, one on each side, over the top and down

on the inside of each nasal cavity, and from the lateral cartilage there appears ingrowths into each turbinal prominence.

"There are certain parts of the chondrocranium which do not ossify, but are lost in the adult. The exact process by which they are resorbed is not known. The following parts are said to disappear: the cornua trabeculae; (2) the cartilage under the nasals; (3) the so-called frontal plate, or that portion of the orbito-sphenoid outside of which the frontal bone is developed; (6) the cartilaginous capsules of the sphenoidal maxillary and frontal sinuses; (7) parts of the turbinal cartilages. Duray has maintained that some of these cartilages do not really disappear by atrophy but by becoming ossified and united with the dermal bones overlying them. Other authors doubt this theory."

In either case, these bones are very susceptible to the influences of the nervous system, since they may require a long period for their calcification.

Influences of disease upon the nervous system act upon these bones, because of their dermal nature, and cause the turbinals to become arrested in development (Figs. 134 and 135) before ossification takes place. The

FIGURE 134
Arrest of development of the turbinates (Zuckerkandl). The inspiration and expiration of air has separated the nasal septum on either side between the turbinates. The cavity is filled with bone tissue.

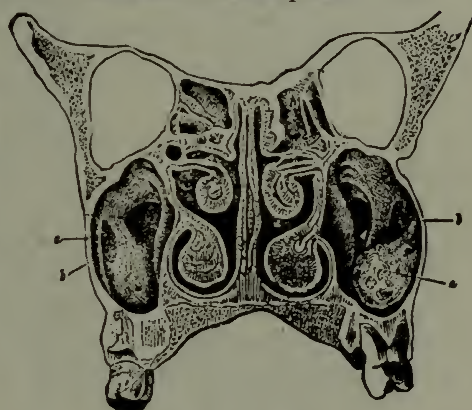


FIGURE 135
Excessive development of the turbinates (Zuckerkandl). The septum is separated its entire length.

inhalation and exhalation of air with an unstable nervous system stimulates an excessive development of one, two or all these bones (Fig. 136), according to their environment and gradual ossification. Likewise, these bones may never develop but are compensated for by other methods (Fig. 134) namely, by an increase in mucous membrane surface due to a thickened septum. The sides of the nasal cavity remain perfectly smooth. To demonstrate, these bones may become entirely arrested or excessively

developed among the primitive races; an examination of the skulls of Alaska Indians and Peruvian skulls in the Army Medical Museum at Washington shows they possess such deformities. I have studied the Alaska Indians in their native country and am free to state that disease, especially lues, has left its mark upon them. The present descendants of

FIGURE 136

Undeveloped turbinates (Zuckerkandl). The superior turbinates have grown and have taken a position midway between the inferior and middle turbinates. Owing to inspiration, the septum on the right side has become detached and has developed into the space between the turbinates.

these people are as badly affected by disease and degeneration as those of modern civilization.

In the development of these bones, the law of compensation is applied equally with all other parts of the bony framework. A given surface in the nasal cavity is required for the purpose of warming the air before it passes into the lungs. As a rule, when there is an arrest of one turbinate, the one on the other side is excessively developed. This is markedly the case in neurotics and degenerates.

Deflection of the Nasal Septum

I purposely reserved the discussion of the nasal septum until the last, for the reason that its position in the nasal cavity depends, to a great extent, upon the position of the turbinated bones. The septum develops from the primordial chondrocranium cartilage and ossifies much more slowly than the surrounding bones. It frequently does not become ossified, especially in neurotics and degenerates, until the twenty-fifth year. It develops in two halves; sometimes they unite, but most always in those children whose nervous systems are unstable they remain separated.

Along the lines of attachment, where it becomes firmly fixed and is much thicker, it grows faster than at the middle where it is very thin.

Abnormal development of the bones of the nose and also their relation to each other, begin at the first intrauterine period of stress. Because of the unstable nervous system, the location of these bones in their relation to each other differs materially. At birth, therefore, deformities and malposition are very common, not from traumatism, but from improper development.

After birth, the inhalation of air stimulates the developing bones in their growth. If the growth be greater upon one side than on the other, arrest will take place on one side and hypertrophy on the other. The law of mechanics in the inhalation of air would call for the septum to take a position midway between the two bodies (Fig. 137). The force of air

FIGURE 137

Diagrammatic scheme of the deflection of the nasal septum (Casselberry). The septum is dependent upon the position of the turbinates for its situation, the object being to assume a position midway and equi-distant from the turbinates.

causes the septum to change its position, like the loose sail of a boat. All the bones of the nose have shortened considerably and have grown smaller in their phylogeny. Their tendency, then, on account of an unstable nervous system and also in response to the stimulus of inhalation and exhalation, is to grow larger in the direction of least resistance and to assume atavistic positions.

The tendency of the septum, influenced by inhalation and exhalation, is to assume a position just midway between the turbinates. It does not always take this position, on account of local conditions. In assuming a position just midway between the turbinals, because of the want of uniformity, the septum takes different shapes and positions, namely, the shape of the letter S, again the letter C and often like the small italic letter *f*. Sometimes it is carried over so far as to approximate the right

or left wall of the nose. When the degeneracy is marked, the position of the attachment, either above or below, may be located at the first period of stress to one side or the other. From the fact that it is attached throughout at its upper and lower border to a solid, bony framework, its middle portion is liable to bend in any direction. Deflection of the vomer, due to fracture of the cartilage, or the deflection of the anterior part of the nose, is easily differentiated from a fractured vomer. Deflection of the septum may take place only in the anterior, middle or posterior third of the bone.

Sharp bends, fracture and separation (Figs. 135 and 138) of the lateral halves of the septum are very common. These are more marked in neuro-

FIGURE 138
Break in the septum between the turbinates of the right side and opposite hypertrophied middle turbinate of the left (Zuckerkandl).

tics and degenerates. The nasal cavity is small, the turbinals are arrested or excessively developed. There is hypertrophy of the mucous membrane with more or less inflammatory action.

When inhalation takes place, the air, passing through the undeveloped passage, produces suction, thus drawing the bone toward that side; while the large volume of air passing through the other larger nostril, forces the bone in the same direction. Thus, by aspiration and pressure, the thinner part of the bone is bent to the weaker side, which gives an unequal space for the passage of air throughout the nose.

When a slight irritation of the mucous membrane takes place, it thickens and the child experiences difficulty in breathing. In the spasmodic effort to draw air into the lungs through the nose, a vacuum is formed and the septum is developed and drawn to the point of least resistance, which would naturally be at a point between the turbinated bones. Again, the outer walls of the anterior nares may collapse, producing the same anomaly. In this manner, the septum takes the outline midway between the bones. The fracture very rarely extends through the two halves of

bone (Figs. 135 and 138) only one side breaking, while the other is simply bent. The fractured half being always upon the convex side leads to the opinion that it is due (1) to the thickening of the mucous membrane, (2) accumulation of moisture or purulent mucus, and (3) an excessive effort on the part of the patient to draw air through the nose. This being impossible, the vomer is drawn into the space (Fig. 138) after partial ossification has taken place and, as a result, fracture of that half and simple bending of the other half takes place. The edges of the broken half are torn apart from the other half, producing a space between which is eventually filled up with bone cells (Figs. 134 and 136). This condition is not unlike a green-stick fracture. Sometimes it will be drawn to the right side in one place and to the left in another.

Again, in the same manner, the two lateral halves are separated their entire length (Fig. 139). There is a projection of the right half at a point

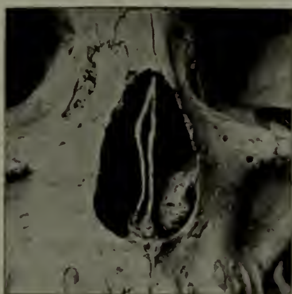


FIGURE 139
Stenosis of the nasal cavity (original). The septum is divided its entire length. Hypertrophy of the right inferior turbinate.

midway between the right turbinated bones. This seems to be only natural, since, in many cases, the deflection and fracture only extend a short distance in the anterior, middle or posterior part of the vomer, while the bone will be perfectly straight anterior and posterior to the deformity. The shape of the deflection and fracture can be accounted for in no other way. In order that fracture may take place, the vomer must have ossified partially or completely, which occurs at middle life; therefore, intrauterine injuries or those occurring before ossification, are out of the question. If the turbinated bones be uniformly developed the vomer will, in most cases, remain quite or nearly straight. The force produced by drawing air will frequently separate the two halves and, occasionally, produce one fracture upon one side, the other upon the other side. Not only are the cartilages of the nose brought into close relation to each other, but, occasionally, the force is so great that there is a total collapse of the outer bony walls

and they are drawn toward the septum, making a groove upon either side, the nasal bones remaining perfectly flat at the upper edge.

Deviation of the nasal septum to one side or the other we conclude is the result of an unequal development of adjacent bony parts, more especially and directly of that of the turbinated bones. It depends largely, if not exclusively, upon the development and position of these latter. They, in turn, are dependent in a great measure upon the development of the facial bones, which are modified as the facial angle increases and prognathism is lost—the turbinated bones being, as it were, exostosed, or entirely wanting, not molded in many directions by adjacent parts, encroaching more irregularly upon the nasal cavity, as their origins are disturbed or dislocated. Freedom of these nasal passages for transit of respired air is essential. In normal respiration the tendency is for both nostrils to share equally. The natural consequence is, that the vomer, the ossification of which is incomplete until puberty, is deflected and occupies, as a rule, nearly a midway position between the bony prominences on either side. Deflection of the septum, hence, is a compensatory arrangement for the evolutionary variations of facial development. It is therefore, most frequent in the higher races, while in the lower its occurrence is markedly less.

Instability of tissue-building is to be expected in neurotics and degenerates. It is easy to see how, with such an unstable bone tissue to build upon, the mucous membrane of the nose and naso-pharynx can take on atrophy, hypertrophy and adenoid growths, resulting in mouthbreathing.

Total collapse of the outer walls of the nose is frequently observed among neurotics and degenerates. This is associated with arrest of development of the bones of the face, jaws, deformities of the dental arch, weak, contracted chest, round shoulders, husky voice. In most cases of this description, the nose is very long and thin. When the patient attempts to inhale air, the outer walls are brought together and nosebreathing is impossible. The result is mouthbreathing, not only taking cold air into the lungs, but disease germs as well.

I have examined over 11,000 skulls in this country and Europe, including the large collection in the Museum of the Royal College of Surgeons, and 347 living individuals, with the following results: Owing to the fragility of the septum, the whole or anterior part was lost in many of the skulls, the results of which were that only 7,600 had sufficient bone remaining to give any idea of its shape. My examination of skulls in the Royal College of Surgeons, London, practically tallies with the Mackenzie report. In the 7,600 skulls, 5,762 showed marked deformities. Out of 687 ancient Peruvian skulls, 147 possessed deflection of the septum. In 69 stone-grave Indians, 35 were normal and 34 deformed. In 18 mound-

builders, 8 were normal, 10 deformed; in 6 California Indians, 4 were normal.

In a collection by J. M. Whitney, of Honolulu, of 28 skulls of ancient Hawaiians, taken from lava caves, the jaws were unusually well developed as well as the bones of the face. The external bones of the nose were also well formed. While there was a lack of that marked asymmetry due to excessive arrest of development of the turbinated bones, as noticed in Peruvian skulls, yet the bones were far from being uniformly located in the cavities of the nose. There were, however, two in which the inferior turbinated bones were undeveloped, only rudimentary ridges being present. Deflection of the septum was noticed in 23 cases—some in the anterior part of the bone, others in the middle, and still others in the posterior part. In the two cases where the inferior turbinated bone was undeveloped, the septum deflected to that side. There were projections which seemed to take the place of the missing turbinates. One case was observed in which the deflection commenced midway, from before backwards, the greatest deformity being three-fourths of its distance into the left cavity, midway between the turbinated bones. Upon that side of the vomer, there was a large ridge, its greatest projection being about .25 of an inch in length. Upon the opposite side there was another smaller ridge, evidently for the purpose of supporting the deflected point, and also for the purpose of affording greater surface for mucous membrane and blood supply. Of the 347 living persons, 107 showed deflection of the septum.

Excessive development of the turbinated bones in ancient skulls is very common. Thus, in the Army Medical Museum, Washington, No. 2,131, case 175, Vancouver Island Indians. The right middle turbinated bone is excessively developed, so that it fills the anterior middle space of the nasal cavity, with a large cavity in the center. The left middle and right and left inferior bones were well developed, filling both nasal cavities. In this case the vomer, which stands uniformly between the turbinated bones, takes the shape of the letter S. No. 2,129, Vancouver Island Indians, shows left superior turbinated bones excessively developed to a level with the middle turbinated bone. The vomer is deflected to the right, then to the left, in order that it may stand in a central position. Skull 1,309, case 173, illustrates the theory of the author very nicely. The right middle turbinated bone undeveloped, inferior right excessively developed; the vomer at its middle takes a V-shape, in order that it may stand in the middle between the terminated bones.

Spurs and supernumerary projections into the nasal cavity are, no doubt, due to irritations and inflammations and in many cases, are for the purpose of giving a larger distribution of the mucous membrane and to supply deficiencies.

Summary

The External Nose

The outer nose, in development, passes from the lower vertebrate snout to the beak-like type of the proboscis monkeys. On account of man's upright position, disuse of facial structures and the senses, the nose is degenerating.

The changes taking place in nose type call for greater bone use to protect the organs of smell analogous to the same conditions which take place in skull development.

In facial development, the nose has assumed types wholly unlike each other. They are normal only when there is no deviation from the type.

The nose may become arrested in its ontogeny at any period from the beginning of intrauterine life on. The more marked deformities are the result of the contagions and infections.

The nose does not always develop harmoniously; the nasal bones and cartilage are often arrested or excessively developed. Sometimes they take opposite directions producing the condition so noticeable among Hebrews and many other races. Mouthbreathing is often a result of excessive development of the nasal bones which fill the air passages.

The abnormal development of the nasal bones and cartilages will cause the nose to be turned to the right or left, depending upon in which side of the nose marked deformity exists. The deflection of the nose produces asymmetry of the face, sometimes slight and again quite marked. Injuries in utero or at birth have been given as causes for marked deflections of the nose, but if one will consider that the bones of the nose are in a plastic state and that deflections do not occur until late in life, this theory is not tenable. The maldevelopment of the facial bones is probably a more rational theory.

The Internal Nose

The first three types of face only concern us in regard to nose development: the first type in which the upper jaw and nose are outside the perpendicular line; the second, inside the line and third, lateral arrest.

The bones of the face, nose and jaw are more often affected by degeneracy due, first, to their position; second, to their shape, position and size; third, to their cartilaginous origin; fourth to their fixity, and fifth, to the early arrest of development of the facial bones.

In the first type, where the nose and upper jaw are well developed

and outside the perpendicular line, the full amount of air can pass through to the lungs. Should there be deformities of any nature, there is no interference in nose breathing.

In the second type, the face is sunken, due to antero-posterior arrest and there is always contraction of the air passages. The upper jaw is small with irregularities of the teeth.

In the third type, or lateral arrest of the face, nose and jaws, the same conditions obtain as in the second. In this type, the air passages are usually closed and mouthbreathing results.

In a comparison of the three types, a great difference will be found between the first, and the second and third. In the first, the bones of the face and jaw are well developed with ample room in the nose for normal inhalation and exhalation of air, with no irregularities of the teeth, while in the second and third types, on account of an unstable nervous system in one or both parents and the child, the bones of the face and jaws become arrested and, as a result, nasal breathing is impossible and irregularities of the teeth are common. Even in the skulls of the primitive races, there is great variation in the measurements of the nose cavities.

Maldevelopment of the Turbinals

The nose bones are of both cartilaginous and dermal growth. The turbinals are cartilage outgrowths from the ethmoidal plate and are easily influenced by disease, especially lues, due to their slow calcification, environment, etc. They may be arrested or excessively developed in the primitive races as well as in civilized. This is nicely shown in an examination of Alaska Indian and Peruvian skulls and in their living descendants. Sometimes the turbinates upon one side will be arrested while those upon the other will be excessively developed.

The Nasal Septum

The nasal septum develops in two halves from the chondrocranium cartilage, ossifies slowly, sometimes not at all, and its position depends upon the turbinals. It is more dense at its attachment than in the middle.

Deformities and malposition of the nose bones are quite noticeable at birth but these are not due to injury in utero, as is generally supposed, but to an unstable nervous system and abnormal development.

On account of its cartilaginous structure, the septum is easily influenced by inhalation and exhalation of air, which causes it to change its position, first being drawn to one side, then the other.

The normal position of the septum is midway between the turbinals,

The abnormal development of these bones, however, cause it to assume different shapes and positions. These shapes, positions and, in some instances, fracture are most marked in neurotic and degenerate states and are more or less intense according to the depth of degeneracy.

Chapter XVI

THE MAXILLARY SINUSES

It has been shown that arrests of the face, nose and jaws in their ontogeny occur at the early periods of stress. Arrests, malpositions and irregularities of the maxillary sinuses must necessarily occur. The two halves of the face as well as the cavities may be asymmetrical.

Types of Antrum are exceedingly variable. Thus in one case the cavity may be small and resemble a crescent with the concavity toward the nasal wall, the convexity toward the malar process. The cavity may not be large enough to admit the end of the little finger and may not extend as far, laterally, as the inferior orbital opening, while the opposite side may be similar in shape and extend just beyond this opening. Sometimes the antrum upon one side will be very long while that upon the other is very small. Usually, in this condition, the nasal cavity will be carried over nearly one half its size to the side of the smallest antrum. There is sometimes soft, cancellated bone extending from the alveolar process into and filling the antrum, leaving a number of small openings or sinuses which resemble the ethmoidal cells. In these cases, the contour of the face is also very much disfigured. A drill passed through the alveoli of the first and second bicuspids would not reach the opening.

Variations in Shape. Although the antrum is usually regarded as a triangle, it assumes even in normal subjects a great variation from this shape. These cavities, located as they are in the superior maxillary bone, which is always subject to arrests in development, are difficult to outline,

Figure 140
Maxillary sinuses extending close to the median line (Zuckerkandl). The opening for these cavities into the nose is located at the upper border. The antra are filled with septi.

Septa are most always present, which partition the cavity into smaller compartments. In the large number of antra examined, I have always found that these septa are attached to the lower border of the cavity extending upon either side. In most cases, there is an opening at the upper border of the septum which prevents the division of the larger cavity into separate and complete smaller ones. It is well to bear this in mind when draining the cavity, since the cavity opened may become well drained while others may remain full of fluid. The variations which may occur are best illustrated in the contrasts between the following cases.

One extreme in variation is Fig. 140 in which the antra, while not alike in size, are peculiarly situated as to location. The external and internal walls are quite thin, allowing for unusual size. They extend almost to the median line and encroach upon the nasal cavity. There are ridges of bone and septa extending throughout the cavity, which are not uncommon in those jaws where the depth of degeneracy is marked. Fig. 141 is an extreme in variation in the opposite direction. The nasal cavities

FIGURE 141
Arrest of the maxillary sinuses and the nasal cavities extending beyond the alveolar process (Zuckerkandl).

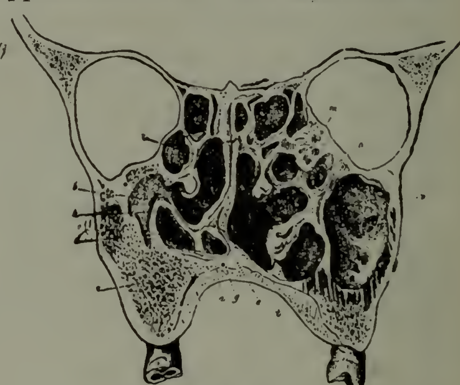


FIGURE 142
The nasal cavities developed to the left side of face (Zuckerkandl). The frontal sinuses, the antra and the nasal cavities are made up of small cavities owing to the depth of the degeneracy.

extend laterally and encroach upon the small antra. The middle and inferior turbinates have developed and adjusted themselves uniformly throughout the cavity.

DEGENERACIES. Fig. 142 illustrates the depth of degeneracy to a marked degree. The maxillary sinuses and the nasal cavities are almost obliterated and the spaces are filled with small cavities. Arrest of the maxilla is more marked in the right, and the left antrum and nasal cavity are blended in one cavity. The septum has separated and developed to

the left. This is a splendid illustration of the struggle necessary in so degenerate a structure to inhale and exhale air, carrying the septum to the center of the nasal cavities, regardless of obstacles. The attachment at the floor of the nares, while in a plastic state, has been actually forced to the left for this purpose. Two small cavities appear beneath the left nasal cavity. The alveolar process and maxillary bone are continuous. The left antrum is entirely obliterated.

Fig. 143 illustrates an arrest of the right and excessive development of the left antrum, which extends downward in the alveolar process. The

Figure 143
Arrest of the right antrum and excessive development of the left (Zuckerkandl). Septa are seen in both antra.

position of these cavities in their relation to the alveolar process and to the nasal cavity are interesting. The antra are partitioned by septa.

Fig. 144 is of interest because the roots of the teeth covered with a thin bony plate and mucous membrane extend into both cavities. When death of a dental pulp occurs, inflammation and abscess are likely to occur upon the ends of the root, causing in turn inflammation of the lining membrane of the cavity.

These illustrations are interesting because of their anatomic relations. In opening the antrum, many operators are of the opinion that the roots of the teeth are in direct line with the sinuses (Fig. 144) and for this reason open this cavity through the alveoli. A close study of the illustrations, show that the opening would occasionally pass directly through the floor and into the nose, or, as in some others, it would be almost impossible to find the antrum.

Abnormalities. On examination of skulls, I have discovered some eight cases where the floor of the nose was so wide and the facial bones so deformed that the long axis of the roots were directed into the floor of

the nose. In each case, the floor of the nose would be perforated were the operator to drill through the palatine and buccal cavities made vacant by the roots of the first or second molars. I have frequently observed arrest of development of the maxillary bone on a line with the alae of the nose, when the alveolar process (in order that the upper teeth might antagonize with the lower) extended outward to such an extent that the apices of the roots of the bicuspids would point entirely outside the line of the antrum. Hence the alveoli are not a reliable route by which to reach the lowest point in the floor of the antrum, nor is the operator sure of reaching it at all. It is easy to see how in a very few cases the development of the antrum and nasal cavities might be such, together with the thinness of the alveolar process, that the roots of the teeth may penetrate

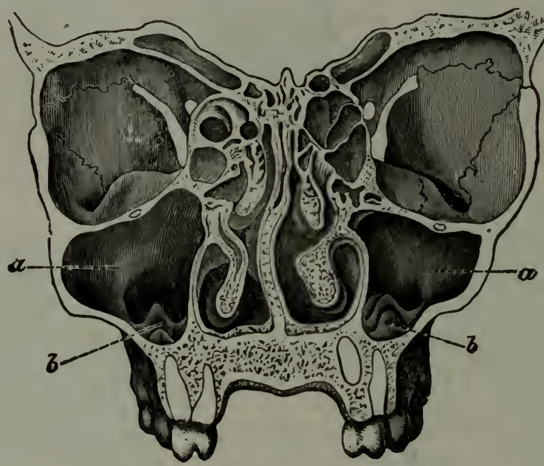


Figure 144
The roots of the teeth extend into the antrum (Zuckerkandl).

the floor of the antrum. These cases, however, are rare. In most cases, owing to the thickness of the alveolar walls and the position of the antrum, the roots of the teeth will not reach it. The roots of the first and second bicuspids almost never enter the floor of the antrum. The roots of the first permanent molar in its relation to the antrum are such that it is almost impossible to penetrate it.

Diseased Conditions. Dr. M. H. Fletcher, of Cincinnati, in an examination of 500 skulls (making 1,000 antra) found 252 upper molars abscessed, making twenty-five per cent of antra which have abscesses in this locality, or every fourth antrum. This per cent is probably smaller than it should be, since many teeth were lost and the alveolar process absorbed. Undoubtedly some of these lost teeth had been abscessed. Out of these 252 possible cases, perforation into the antrum was found

only twelve times; thus showing over four and one-half per cent, or about one in every twenty-one of the abscessed teeth in this locality, which are connected with the antrum.

In my own examination of 11,000 skulls, only 3,000 were found in a broken condition so that the antra could be examined, making 6,000 antra in all. Of this number 1,274, or about 21 per cent had abscessed molar teeth. Of this number 76, or about 6 per cent, extended into and apparently discharged into the antrum. As specialists were unknown among the ancient people whose skulls were examined, a larger percentage of abscessed cavities would occur than at present, due to lack of treatment. Septa were found in 963 cases. These ranged all the way from a simple ridge running along the floor to a partition extending two-thirds the height of the cavity. Again, several septa occurred in all directions which gave the appearance of ethmoidal cells extending throughout the entire cavity.

Dr. M. H. Fletcher found in 224 cases of pulpless molar teeth among his patients only one case of pus in the antrum. In the treatment of 367 cases of pulpless teeth in connection with the superior molars in the past forty years, only three cases of diseased antra were noticed by me, making less than three per cent of diseased antra.

In the treatment of diseases of the maxillary sinuses, dead teeth and their abscesses should first be considered and excluded before considering other causes. Owing to the variation in location and deformity, the safest operation is to enter the antrum through the nasal cavity, at which point it can be thoroughly explored, drained and treated. The patient should be requested to lie first upon the back; then upon the face with the head down. Should there be any septa in the sinus, the fluid will, in this way, be easily drained.

Summary

At the early periods of stress when arrests of the face, nose and jaws take place, it necessarily follows that the maxillary sinuses must be involved at the same period.

Of all the sinuses, the antrum is probably the most variable. It assumes various shapes, may be large or small and is often filled with septa which separate it into several cavities. The treatment of the antrum when septa are present is difficult, owing to the fact that one cavity may be well drained while others remain in a diseased state. Located as it is in the superior maxillary bone, which is always influenced by an unstable nervous system, the antrum even in supposedly normal individuals may be far from a triangular shape usually considered normal.

Extremes in the location, size, density, etc., have been nicely brought

out in the illustrations, which also show how markedly this cavity is affected by degeneracy.

Many operators believe that the roots of the teeth are in direct line with the antrum and therefore attempt to open it through the alveolar processes. This is not a safe procedure as oftentimes an opening will be made through the floor of the nose and the antrum never be reached.

From skull examination, I have found eight instances where the roots of the teeth were directly in line with the floor of the nose and an operator using the sockets of the first or second molars would penetrate the floor of the nose. Frequently arrest of the maxillary bone causes the alveolar process of the jaw to protrude to the extent that the ends of the bicuspid roots will be entirely away from the antrum. So to open the antrum through the alveolar process is a very risky operation. There are rare instances, however, in which the roots of the teeth penetrate the antrum floor. Seldom do the roots of the bicuspid teeth enter the antrum and the first permanent molars never. Dr. M. H. Fletcher's examination of 500 skulls and my own of 11,000 bear out this conclusion. The safest method to enter the antrum is by way of the nasal cavity.

Chapter XVII

THE JAWS

THE variability in human jaw development is easily understood when one takes into consideration the evolution in phylogeny, the factor of disuse, the dermal structures and the various obstacles encountered in ontogeny.

The shortening of the jaws from before backward; the diseases encountered in parent and child involving the nervous system; the fixed position of the upper jaw, it being developed in connection with the bones of the skull; the mobility of the lower jaw and its development independent of all the other bones of the body,—the wonder is that the teeth ever develop in harmony with each other. While it is true that in any given patient the two halves of the body may be asymmetric, the contrast between the two halves because of their distance from each other, is not nearly so noticeable as a like degree of asymmetry in the jaws and teeth. The minutest detail in contour, shape and position of the jaws is immediately detected because of their close proximity and because of their appearance in facial expression. The position of the teeth is also readily observed, since symmetry adds greatly to the appearance of the individual.

In the study of deformities of the face, nose, jaws and teeth the fact must not be lost sight of that, when these structures are involved, the line of least resistance may be in both directions, therefore excessive development of these structures may ensue as readily as arrest.

The tendency in jaw development is along the line of least resistance, that is, toward large well developed jaws like those of our ancestors (Fig. 91). Disuse of structure and disease has obtained mastery over their development, and the material intended for jaw development has been appropriated, under the law of economy of growth, to other structures, namely, the brain and skull. Owing to an unstable nervous system, it is possible for atavisms manifested in large jaws to occur. Hence both jaws may in some persons develop like those of our ancestors, or one jaw may develop large and the other small. The larger one is an arrest in phylogeny and the smaller an arrest in ontogeny. Again part of one jaw, as the body of the lower, may develop large and long, while the rami may be normal in size or arrested in development, or the rami may develop large and long, arrest in phylogeny, and the body be normal in size or arrested in ontogenetic development. Again one side of the rami, or body, or both, of the jaw, may become excessively (phylogenetic) developed and the other side remain normal or arrested in ontogenetic development.

Under such conditions, the face not only becomes markedly deformed,

but the teeth are also irregular and out of their normal position. In an examination of 1,977 idiots, there were found to be 159 with protruding superior maxilla and 92 with protrusion of the inferior maxilla. In an idiot boy of thirteen at the Hamburg, Prussia, School of Idiocy, the lower jaw was excessively developed one and one-half inches beyond the upper.

The upper jaw is more liable to become arrested than the lower. This is due to the fact that marked arrests take place in utero at the first period of stress (Fig. 145—a skull at birth). The brain continues to develop in all directions extending forward over the face. The lower jaw is less liable to become arrested because of its mobility and because it is developed independently of the other bones of the body. When, however, arrest of the lower jaw does occur, it is always an indication of marked depth of degeneracy, to which the system of the child is subjected, as in idiocy, rickets, tuberculosis, etc.

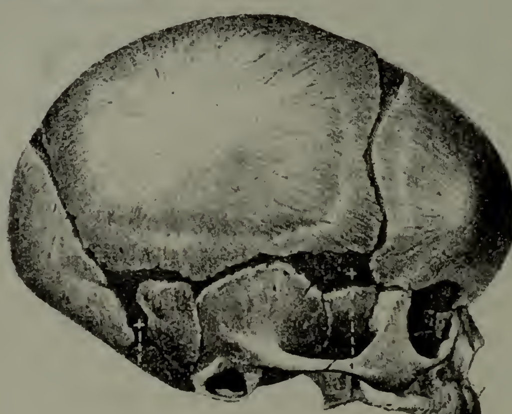


FIGURE 145
Skull at birth showing arrest of the face and superior maxilla (Spoldeholtz).

The accustomed eye can easily detect the degenerate face and jaw bones (arrests in ontogeny) at birth. In studying the skulls (Figs. 44 and 45), the one at ten months shows arrest at the nasal bone, while the skull at birth shows a marked arrest of the face. The lower jaw at seven months and that at twelve months shows excessive development. The face at twenty-two months and at two years is markedly arrested, while the lower jaw at three years and six months is also arrested. All these deformities may become more exaggerated in bone development or they may develop near the normal.

The changes which take place in the jaws and teeth are best studied in the negro. Those children who are the descendants of three or four generations living in the older cities, especially in Boston, are of interest.

Here the great changes are marked and represent not over 250 years. The same degeneracies in the Caucasic race have required thousands of years. Arrest of the jaws in very marked degenerate children from one to five years of age with deformed dental arches are occasionally seen.

Arrests and excessive development of maxillary bones, however, are not very pronounced in connection with the first set of teeth. They do not develop their full degree of degeneration until the individual is from twenty to thirty years of age. A few of the more marked deformities, frequently observed by the stomatologist, are here illustrated.

Fig. 146 represents the jaws of a patient, twenty-six years of age, in whom, on examination, was found a small normal inferior maxilla, well

FIGURE 146
Excessive development of the superior maxilla (original).

protruded and in harmony with the other features of the face. The superior maxilla and alveolar process were excessively developed, the first molar and anterior teeth describing a much larger circle than the lower. The second molars were the only teeth that articulated properly. The anterior alveolar process had taken on a prolific deposition of bone cells, until the teeth impinged upon the gum of the lower jaw, producing absorption. The upper jaw may be considered an atavism and arrest in phylogeny, while the lower is an arrest in ontogeny. The upper lip was covered with a mustache which completely hid the deformity. Under such conditions a prominence is observed at the alae of the nose—the upper lip being drawn tight over the alveolar process. The cause of this class of cases may be a local one.

Fig. 147 represents a case occasionally met with. The body of the inferior maxilla is excessively developed, the extent of the irregularity depending on the degree of development. When only a slight protrusion exists, the inferior incisors strike beyond the superior incisors. In extreme cases only the molars articulate. When the anterior teeth articulate, the

alveolar process develops so that the teeth extend to the superior alveolar process. The features may be otherwise quite regular. Asymmetry of the jaws often continues to develop until the osseous system has obtained

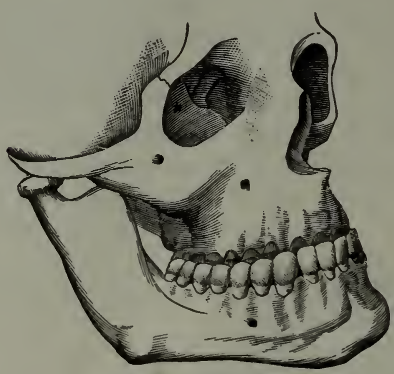


FIGURE 147
Excessive development of the lower maxilla (original).

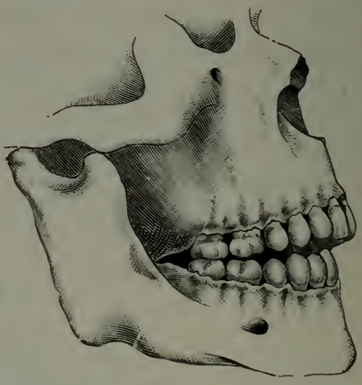


FIGURE 148
Excessive development (hypertrophy) of the superior alveolar process downwards (original).

its full growth. The upper jaw is an arrest in ontogeny, while the lower jaw is an arrest in phylogeny. This deformity is common among negroes.

Fig. 148 is that of a fourteen-year-old boy. Before the eruption of the second molars, the articulation was perfect. As soon as the second molars occluded, the jaws were forced open. This deformity is due to two causes; first, there is an excessive development downward of the alveolar process; second, the rami are so short that when the second molars developed the line of articulation was changed. The inferior maxilla is not well developed, nor has it the power to overcome the resistance and force the superior alveolar process and teeth forward, as exemplified in next illustration.

When the rami are so short that they do not harmonize with the maxillary bones, the movement of the jaws may be likened to that of the arms of shears; the farther the points are from the center, the greater the distance they have to travel. A slight movement at the center will cause them to move a considerable distance. In a similar manner, a slight excessive protrusion of a molar will cause the anterior teeth to become separated. The shorter the rami, the less the harmony between the jaws and teeth; the farther back the protruding molar and the more it projects, the greater the anterior separation of the jaws. The excessive eruption of the second and third molars is very often due to the person's sleeping with the mouth open; the pressure upon the posterior teeth being removed,

the alveolar process will elongate and carry the teeth downward. Not infrequently the malocclusion of the teeth is due to the inability to close the jaws on account of the inharmonious development.

Occasionally there are mouths in which the molars and bicuspids occlude, and there is just enough space between the centrals to admit a thin spatula. In January, 1887, a patient was brought to the writer for advice whose jaws, when closed, showed a space of half an inch between the incisors. Such cases are due to arrest of development of the anterior alveolar process, the superior dental arch being too small for the inferior. The pressure of the jaws upon the molar teeth is, in some instances, so great that normal eruption is impossible. In such cases, the molars will protrude through the gum and the superior and inferior processes will occlude when the jaws meet.

Fig. 149 shows the opposite condition to Fig. 148. Here the upper

Figure 149
A weak upper alveolar process and a strongly developed lower jaw (original). Arrest of the rami is quite noticeable.

jaw is the weaker of the two. The rami is short and there is a want of harmony in jaw development similar to the last illustration. The force of the heavy lower jaw against the weaker upper has carried the teeth and alveolar process forward until articulation is normal. The result is, however, that the incisors and alveolar process protrude in front.

Fig. 150 shows an excessive development of the rami and an arrest of development of the body. The excessive development of the rami has caused the body of the jaw and the teeth to protrude beyond the upper teeth. When such a deformity is associated with arrest of development of the superior maxilla, it is extremely difficult to restore the features to a

normal expression. In this illustration, the second molar on the upper jaw and the third molar on the lower were found to be the only teeth that occluded. In connection with this deformity, there was a marked arrest of development of the bones of the face.

Fig. 151 shows the reverse of Fig. 150. There is an arrest of development of the rami and excessive development of the body of the lower jaw,

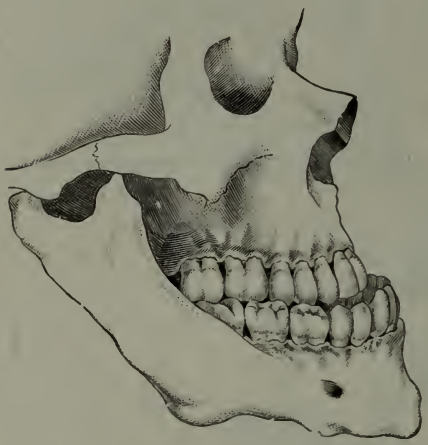


FIGURE 150
Excessive development of the rami (original). The body of the jaw for this reason has been carried forward.

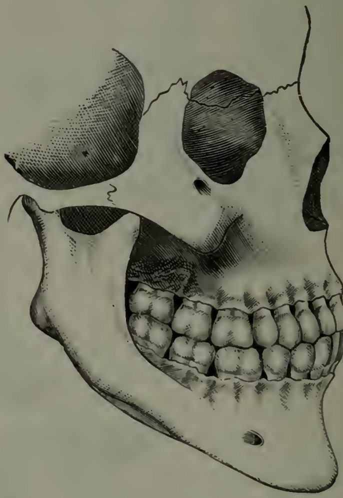


FIGURE 151
Reverse condition of Fig. 150 (original). A marked arrest of development of the rami with excessive development of the body allowing the teeth to articulate normally.

with a protruding chin. The lower jaw is small, thin and very delicate. In such patients, dislocation of the inferior maxilla is liable to occur while yawning, scolding, or during dental operations, so great is the leverage.

Excessive development of the jaws is not uncommon. It frequently takes the direction of least resistance, arrest in phylogeny, and resembles the lower negro type. In such patients the muscles are large and heavy, the jaws well set and the teeth large and evenly located without irregularities. When the jaws are developed larger than the type (atavistic), the teeth are always large and hard, the surfaces smooth and they seldom decay.

Fig. 152 illustrates a normal superior maxilla and rami, with arrest of the body of the jaw, including the chin. The deformity is a very common one, most markedly observed among idiots, and produces an unsightly appearance.

Fig. 153 is that of a young lady twenty-three years of age, reported by Dr. Vilray Papin Blair, in the Journal of the American Medical Association for July 17, 1909, showing an arrest of the inferior maxilla. She had scarlet fever at two years with mastoid suppuration of each ear.

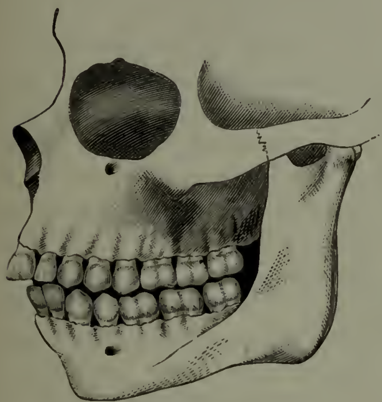


FIGURE 152
Arrest of the body of the lower jaw (original).

FIGURE 153
Arrest of the inferior maxilla (V. P. Blair).

Complete absence of the inferior maxilla, as Gould remarks, is much rarer in man than in animals, but it does occasionally occur (Fig. 154).

FIGURE 154
Complete absence of the lower maxilla (Sutton). Opening at the first gill cleft. An arrest in phylogenic development at the fish stage. The ears are developed out of their normal position.

Nicholas and Prenent have described a case of this in a sheep. Gurlt has observed cases with total or partial absence of the inferior maxilla. Simple

atrophy of the inferior maxilla occurs in man and the lower animals, but is much less frequent than atrophy of the superior maxilla. Langebeck reports the case of a young man who had the inferior maxilla so atrophied that in infancy it was impossible for him to take the breast. The patient had nearly complete immobility of the jaws. Boullard reports a facial deformity with deficiency of the condyles of the lower jaw. Maurice has reported a vice of conformation of the lower jaw which rendered lactation impossible. Tomes describes a lower jaw, in which the development of the left ramus had been arrested. Canton describes an arrest of development of the left perpendicular ramus of the lower jaw, combined with external malformation. Animal breeders have taken advantage of these peculiarities in jaw development and have developed types which have become fixed. Thus, the domestic hog has been developed with very short jaws, which were originally very long. Different breeds of dogs have been raised, some with long jaws, others with short and still others with the upper jaw arrested in development, all of which sprang from the original wolf dog. It will be seen, therefore, that since such deformities may easily be produced by deliberate purpose in the lower vertebrates, they may occasionally occur by fortuity in jaw irregularities among the human. In like manner the shortening of the human jaws may be produced by the continual extraction of the temporary and permanent teeth, generation after generation. The vicious habit, so common in some countries, of extracting the first permanent molar to prevent crowding, will produce the same result. The rapid decay of the teeth, thus preventing the crowding of the crowns against each other to expand the arch, is another fruitful cause of jaw arrest. By the careful observer many other deformities of the jaws, not here illustrated, will be found among the defective classes.

Summary

Evolution and disuse together with other ontogenetic conditions play an important part in the development of man's jaws. The shortening of the jaws, neurasthenic conditions in both parents and child, fixity of the upper and mobility of the lower influence the eruption of the teeth. While asymmetry of other parts of the body may escape observation, any variation in jaw development and tooth irregularity is easily detected.

Disuse, disease, an unstable nervous system, too early or too late extraction of the temporary teeth, together with brain and skull gains in human evolution, have caused the jaws to become arrested or excessively developed. These stigmata of jaw degeneracy are well illustrated in idiocy.

The lower jaw, on account of its independent development and mobility is not so easily affected by degeneracy as the upper, which often becomes arrested at the first intrauterine period of stress. The evolution of the negro in 250 years is the best example of jaw and tooth change. There is rarely arrested or excessive development with the deciduous teeth. The deformities occur later in life in connection with permanent tooth eruption.

Large or excessively developed jaws are an atavism and resemble the lower negro type. In these instances the muscles are tense, the teeth well developed and hard without decay or irregularities.

Instances of the absence of the lower jaw have been reported by many investigators.

Chapter XVIII

THE DENTAL ARCHES

DENTAL arches of early races, as observed in their skulls and those of primitive races now living, do not show the deformities seen in modern races.

In the evolution of man, his jaws and teeth attained their highest physical development when they reached the perpendicular line (Fig. 92) and still contained thirty-two well developed, hard, sound teeth, in their proper positions, with plenty of room between the third molars and the angle of the jaw. Such jaws and teeth are to be found in primitive early races. Some of the jaws of the more primitive races measured 2¾ to 3 inches in lateral diameter (Fig. 155). Since that period man's jaws have

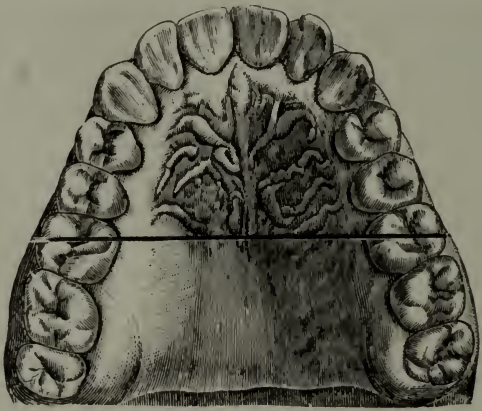


Figure 155
A normal dental arch (original). This arch is a little larger than the average normal at our present stage of evolution.

degenerated, the normal jaw of the Caucasic races now having an average measurement of about two inches.

Line of Jaw Development. A study of the jaws and teeth of peoples living today will demonstrate that deformities of the dental arch increase in proportion to the evolution and degeneration of the face inside the perpendicular line. In nationalities where the jaws are the smallest (English) the most marked deformities of the dental arch are observed. Arrest and excessive development of the jaws due to an unstable nervous system in parent and child furthers the diminution of the already small jaws. While the evolution of man, in which the brain is growing larger and the face and jaws are growing smaller, is a normal healthy process, it

is the unstable nervous system which causes the further arrest. In large, well developed jaws, there is plenty of room for thirty-two well developed teeth. These teeth are situated in their normal position. As the jaws grow smaller, the teeth do not decrease in size to correspond to the size of the jaw hence irregularities occur. The reason for this want of harmony in tooth and jaw development is interesting. All structures of the body develop, as we have seen, from a primitive cell. This cell divides into two cells, these into four, four into eight and so on until the structure has developed to its full size. While this development in ontogeny is going on, arrests may take place at any period before full growth has occurred.

The Development of the Teeth, however, is an exception to this rule. The dental papilla follows the same law, and is influenced by systemic diseases like other structures. The teeth, therefore, do change their shapes and do grow smaller in the evolution of man, but not in proportion to the evolution of the jaws. The enamel organ, on the other hand, is developed from a fullgrown epithelium and not from a primitive cell. This epithelium, when it has assumed the shape of the tooth to be formed, calcifies at the periphery of the dentin bulb, thus fixing the shape and the size of the tooth. The rule of ontogenetic development, therefore, does not obtain in the enamel organ. While such marked diseases as syphilis, tuberculosis, etc., in parents and the eruptive and constitutional diseases in children will, to a certain extent, affect the enamel organ in its local arrangement of epithelial cells before or at the time of calcification, the depth of degeneracy is not so great as it is upon tissues of the body developing from a single cell, especially the jaws.

The eruption of the teeth, if they develop in their natural order and position, will wedge their way, to a certain extent, and enlarge the jaw. Not infrequently the arrest is so great, and, because of an unstable nervous system, the bone cells are deposited in such a dense form that the force is insufficient to produce absorption and enlarge the jaw. The alveolar process builds itself naturally about the roots of the teeth, no matter how large, small, or irregular the dental arch may develop.

Irregular Dental Arches (individual) are rarely, if ever, observed in connection with the temporary teeth. This is due to the fact that the jaws continue to grow during the second and third periods of stress. The stimulation of bone cells in developing the jaws is, no doubt due, in a degree to the irritation set up by the dental crypts of the second set of teeth. This environmental stimulus is sufficient, in many cases, to overcome the general arrest of the jaws at this time.

When, however, irregularities of the dental arch occur with the first set of teeth, the antero-posterior or lateral degeneracy is most severe upon the face and jaws, at or before the second period of stress. Occasionally,

there is some local cause, as sucking of the thumb or other substances or other local interference.

An irregular dental arch of the second set of teeth is a purely local mechanism. Given a small arrested jaw, on the one hand, and a set of teeth the long diameter of which, when in normal position, describes a larger circle than the circle of the jaw, on the other, a break must essentially take place at the weaker parts of the jaw circle.

The development of the teeth and the position they occupy upon both sides of the median line, are rarely alike. The reason for this is that the environment is rarely the same upon the two sides. The two sides of the jaw may not develop alike owing to an unstable nervous system; one side may have a more dense deposit of bone cells than the other; there may be hypertrophy of bone upon one side and not upon the other. The germs of the teeth may not be located in identical position on both sides. In the eruption of the teeth, obstacles may be in the way of a

FIGURE 156
A V-shaped dental arch (original).

FIGURE 157
A saddle-shaped dental arch (original).

normal healthy development and position, during or after eruption. Since the two halves of the jaw do not develop alike, for a clear understanding of the position taken by the teeth, an imaginary line must be drawn through the jaws at the median line dividing the superior and inferior dental arches into two lateral arches upon each jaw; the first permanent molars being the posterior bases, the central incisors the anterior bases and the cuspids, the keystone to each lateral arch. This order is the basis for the development of the V dental arch and its modifications. In the formation of the saddle arch and its modifications, the anterior base is changed from the

central incisor to the cuspids which then become the fixed point, or base, in the anterior dental arch.

The Eruption of the Teeth is not unlike a game of checkers or chess. Upon the wisdom displayed in the first few moves will depend who wins the game. The same is true in regard to the type of irregular dental arches.

There are two typical forms of irregularities of the teeth, namely the V dental arch (Fig. 156) and the saddle dental arch (Fig. 157). All other deformed dental arches are simply modifications of these two. Which form of dental arch develops in a given jaw will depend upon which teeth erupt first and the time of the eruption, after the first permanent molar is in place. Eruption of this tooth is the first move in the game. It must

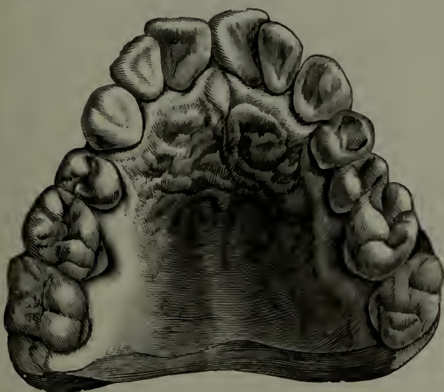


Figure 158
A partial V-shaped dental arch (original).

Figure 159
A semi-V-shaped dental arch (original).

not be assumed that irregular tooth development is a game of chance and that the teeth come into place in haphazard fashion; such is not the case. The position the teeth assume in the V and saddle arches, and the position they try to assume in their modifications (but are interfered with by environment), is governed by laws (phylogeny and ontogeny) just as fixed as the laws which govern malformed structures in other parts of the body. The jaw bones *per se* are an arrest in ontogeny, while the V dental arch is an arrest in phylogeny at the fish and reptile stage and the saddle dental arch at the carnivora stage.

The Classification of Deformed Dental Arches was not an easy matter. It required eight years and a collection of more than 3,000 models. The more marked forms were first placed into groups, then the less marked, and so on until all had been grouped. From these groups, the following forms were obtained. No two models were exactly alike, showing con-

clusively that the malformations could not possibly be moulded by any external process.

Fig. 158 shows a partial V-shaped dental arch, Fig. 159 a semi-V. Fig. 160 presents a partial saddle-shaped dental arch, Fig. 161 a semi-saddle.

A closer observation will disclose a group of models in which there is

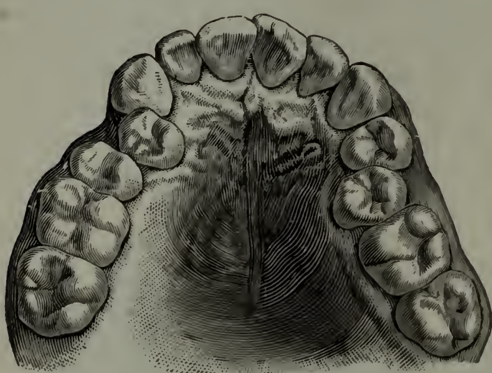


Figure 160
A partial saddle-shaped dental arch (original).

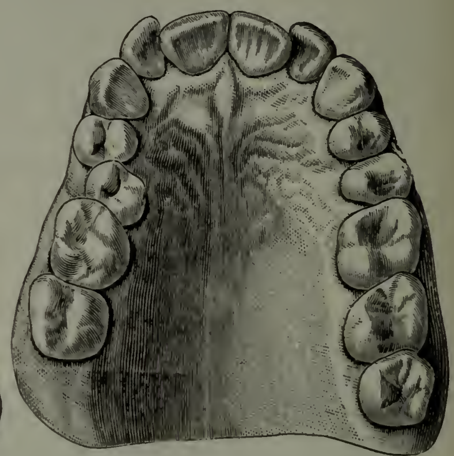


Figure 161
A semi-saddle-shaped dental arch (original).

a blend between the V and saddle-shaped dental arches (Fig. 162). There is a great variety of these two forms, influenced by local environment in tooth eruption. They would assume the definite V or saddle-shaped forms were it not for local interference.

Figure 162
A V and saddle-shaped dental arch combined (original).

Deformed dental arches due to local environment are not considered in this work. These and the details of the formation of the V and saddle-shaped arches and their modifications have been fully explained in the author's work "Irregularities of the Teeth."

Summary

The acme of perfection in the teeth of man is marked by the perpendicular line, by thirty-two well-developed teeth, and plenty of room between the third molar and the angle of the jaw. This perfection is most observable in primitive races.

Deformities of the dental arch are in proportion to the evolution of the face inside the perpendicular line (degeneration).

The teeth, while they do grow smaller in the course of evolution, do not keep pace with the diminishing jaw. To this are due irregularities of the dental arch.

These irregularities rarely occur during the first teeth, as the jaw is then still growing.

Irregular development of the dental arch is asymmetrical, because the environmental influences are not the same upon both sides.

The types of arch are determined by the disposition of the first few teeth erupted, and are defined according to an imaginary median line.

There are two general types, the V and the saddle arch, of which all others are modifications.

These two types are arrest in phylogeny, the V dental arch to the fish and reptile, the saddle dental arch to the carnivora.

Chapter XIX

THE ALVEOLAR PROCESS

THE alveolar process (Fig. 163) is a soft, spongy, provisional bone, situated upon the superior border of the inferior maxilla and the inferior border of the superior maxilla. These bones are considered a part of the maxillary bone and are so described by anatomists. They should, however, be considered as practically separate and distinct bones, for the reason that they are exceedingly transitory. Their structure and

Figure 163
The upper jaw and alveolar process after the teeth have been removed (original).

function, moreover, differ completely from the structure and function of the maxillary bones.

Development of Alveolar Process. At birth, the alveolar process is not present. It does not make its appearance until the first teeth develop. At birth, the sacs containing the crowns of the teeth are nearly or quite enclosed in their soft bony crypts. When the teeth erupt, the alveolar process, being soft and spongy, moulds itself about the roots after their eruption, regardless of their position in the jaw. As the teeth erupt, the alveolar process develops upward and downward with the teeth until it attains the depth of the roots of the teeth, which extend, in most instances into the maxillary bone when the roots of the teeth have completely developed. The teeth develop upwards and downwards until a resting point is acquired which is in harmony with the development of the rami. The depth to which the roots penetrate the bone differs in different mouths.

This depends upon the length of the root and the alveolar process. The fact that some of the teeth are fixed in the bone itself as well as in the alveolar process makes the correction of some forms of irregularity more difficult, for not only is the process re-shaped, but the bone as well. This is quite noticeable in correcting irregularities of the teeth in the lower maxilla. The crypts of the permanent teeth are located at the apices of the roots of the temporary teeth. The permanent teeth have large crowns

and long roots, which require a much larger circle in the jaw and alveolar process. It is natural, therefore, as man develops and grows in size, for the jaws and alveolar process to develop larger for the second teeth to come into their normal position.

In the previous chapter, it has been shown the two lateral dental arches do not develop uniformly; one lateral dental arch may be normal, while the other may be a V, saddle-shaped, or some one of their modifications. Again, one lateral dental arch may be a V or saddle-shaped and the other a mixture of both (Fig. 162). The alveolar process will mould itself about the roots of these teeth and change the shape of the vault to correspond with the contour of the teeth.

The alveolar process is composed of two plates of bone, an outer and inner, which are united at intervals by septa of cancellous tissue. This form of alveoli is for the reception of the roots of the teeth. In some cases, the spreading of the maxillary bones by wedging, as the teeth come into their normal position, is so great that the deposition of bone cells cannot develop in harmony with the size of the dental arch. Not infrequently, the buccal surfaces of the roots of healthy teeth extend nearly or quite through the outer bony plate and are only covered by the peridental and mucous membranes. The inner plate is thicker and stronger than the outer, for the reason that absorption of the alveolar process does not keep pace with the lateral advancement of the rapidly growing maxillary bone, because of lateral pressure. Discrepancy in development of the outer and inner plates of the alveolar process is thus accounted for. The thinness of the outer plate of the alveolar process, and its frequently observed absorption, due to irritation by too vigorous use of the tooth brush over the cuspid and other teeth, results.

In jaw evolution with arrest of development, there develops, in some instances, a high vault. There is a tendency also to lengthening of the rami, owing to an unstable nervous system. The crowns of the teeth also are changing their shape owing to the evolution of the face. The teeth are growing smaller in diameter, but longer in length of roots. This is a good illustration of the law of compensation, for since the jaws are growing smaller the roots are obliged to lengthen to support mastication.

With these natural changes, and because in many cases the nasal cavities are smaller and filled with hypertrophied bone and mucous membrane, mouthbreathing results. Any one or all these conditions cause the jaws to assume a wider distance between each other. It is natural for the alveolar process to grow upwards and downwards until the teeth come in contact with a resistance. *The lengthening of the alveolar process, therefore, produces a higher vault, no matter what the size of the dental arch may be.*

Function and Mechanism of Alveoli. The alveoli are lined with

a thin plate of bony substance extending from the outer and inner plate of the alveolar process to the apex, where there are small openings for the entrance of nerves and blood vessels for the nourishment of the teeth.

The teeth are held firm in their alveolar sockets by a union called gomphosis, which resembles the attachment of a nail in a board. Teeth with one conical root and those with two or more perpendicular roots, are retained in position by an exact adaptation of the tissues. Teeth having more than one root, and those bent or irregular, receive support from all sides by reason of their irregularity. The teeth are also held in position by the peridental membrane. In Fig. 164 is seen the position of the teeth

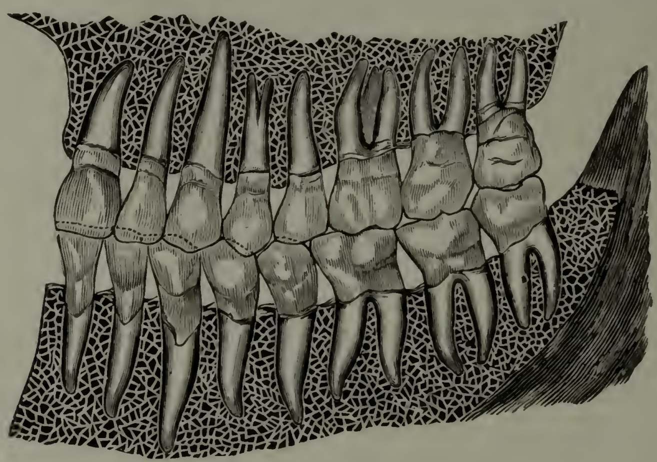


FIGURE 164
Superior and inferior maxillary bones and teeth with the outer plate of alveolar process removed (original).

in the jaws. The peridental membrane lining the alveolus and covering the roots of the teeth is a fibrous tissue, which admits of slight motion of the teeth and acts as a cushion to protect the jaws from severe blows and concussion while tearing and grinding food. If, for any reason, the teeth do not erupt, the alveolar process is not present. On the other hand, when extraction is necessary or if the teeth drop out on account of interstitial gingivitis, the alveolar process absorbs (Fig. 165).

When teeth are moved for the purpose of correcting irregularities, the alveolar process will absorb on the one hand, and build itself around the tooth in its new position, at any period in the development of the growing child. When, however, the child has obtained its growth, because of its transitory nature and because of the fact that the alveolar process has completed its function, new bone rarely is deposited about the roots of the teeth.

So rapid is the tendency of the alveolar process to develop between the sixth and twelfth year (the second and third periods of stress) that not infrequently when teeth are misplaced they can be directed to their normal

FIGURE 165
Superior and inferior maxillary bone. Absorption of the alveolar process where the teeth have been removed (original).

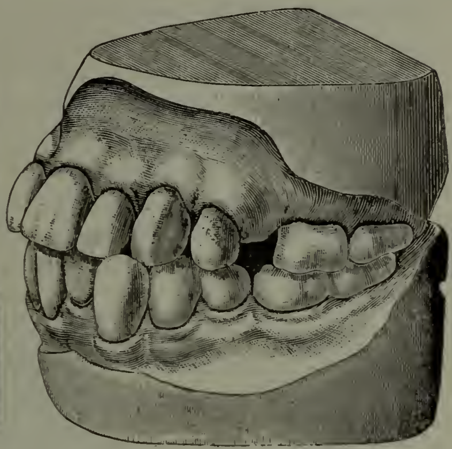


FIGURE 166
Enlargement of the anterior superior alveolar process influenced by the lower teeth (original).

position by slight mechanical assistance. The crowns of the teeth themselves, while erupting, wedge their way into position and with the help of the developing bones enlarge the dental arch (Fig. 166). No matter what position the permanent teeth may take the alveolar process, being a transitory structure and only intended to hold the teeth in place, moulds itself about the roots of the teeth.

There are from twenty-eight to thirty-two foreign bodies (teeth) set on end in a vascular, transitory, bony structure (the alveolar process). Children with unstable nervous systems, not infrequently have an extra deposition of calcium salts in the alveolar process which causes the bone to become very dense and hard. This may occur in the entire length of the alveolar process or only one side may be involved; again, only the space in which one, two or three teeth may be located. This excessive deposition of bone cells in the alveolar process may occur at the eruption of the temporary as well as of the permanent teeth. An excellent illustration of this developmental pathologic condition is seen in the late eruption of the temporary and permanent teeth. The bone becomes so dense that sometimes the incisors do not make their appearance for a year, and sometimes much later.

DEPOSITION OF SALTS. Excessive deposition of bone salts is again

illustrated in the alveolar process at the points of eruption of the premolars. Not infrequently these premolars are not shed, and the alveolar process does not expand in harmony with the bone, the permanent molars and the six anterior teeth. As a result the crowns of the bicuspids are held between the roots of the temporary molars, which, when developed, occupy a smaller circle than the permanent teeth. It is this late eruption of the bicuspids that most largely assists in the formation of the saddle-shaped arch. We observe this dense bone structure in connection with the eruption of the incisors of the second set of teeth. Not infrequently, after the roots have become absorbed and the temporary teeth removed, bone cells are so densely deposited over the crowns of the permanent teeth that it is with difficulty they can bring about the absorption of the alveolar process necessary for their appearance. Again, the density of bone about the roots of teeth may cause slow eruption of the permanent teeth; or the bone may become so dense that the teeth can hardly push their way into the mouth, so that the alveolar process will barely expose the entire crowns of the teeth.

Injuries to the temporary teeth, such as blows, will cause a deposition of bone cells about the roots, thus retarding the eruption of the permanent teeth. On the other hand, injuries and alveolar abscesses to the first teeth frequently cause interstitial gingivitis and bone absorption, exposing the crowns of the permanent teeth.

The irritation produced by the eruption of the teeth in those children possessing an unstable nervous system may be so great as to cause hypertrophy of the alveolar process. This may not be apparent upon observa-

FIGURE 167
Hypertrophy of the superior alveolar process throughout (original).

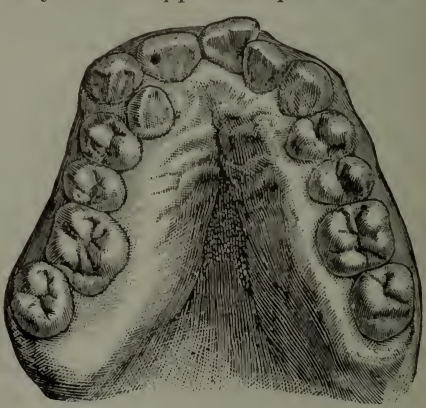


FIGURE 168
Hypertrophy of the alveolar process throughout (original). The right alveolar process because of the hypertrophy has carried the teeth out of position.

tion, yet the bone in its arrested form may not expand sufficiently for all the permanent teeth to come into place. Not infrequently, in more markedly degenerate children, there will be no room for the cuspids, which may or may not erupt outside of the dental arch. In more profound degeneracies, hypertrophy, owing to an unstable nervous system and to the local irritation of erupting teeth, may be in evidence (Fig. 167). In this particular instance, many of the points previously mentioned are noticeable. The jaw has not developed; the teeth are only partially erupted; while the cuspids are outside of the dental arch. Fig. 168 shows hypertrophy of the alveolar process to such a degree that the vault is almost obliterated. The teeth were slow in erupting and the expansion of the arch was impossible. Fig. 169 shows an arrest of development of the

Figure 169
Hypertrophy of the alveolar process in connection with three left superior molars (original).

entire bone, with a V-shaped arch on one side and a semi-V and semi-saddle shaped arch on the other, and hypertrophy of the alveolar process which has prevented the molars from erupting.

With such a picture in view, I can but condemn the vicious practice of undertaking to correct like irregularities by means of pressure, in this unstable type of children, a measure which must be accomplished at or about the third period of stress. How much more to be condemned is the practice of trying to expand the arch without extraction.

Microscopic Aspects. Having considered the alveolar process in its gross aspects, its microscopic aspect will now be studied.

Under the microscope, two systems of Haversian canals are seen in

the alveolar process. These Haversian canals, according to Kolliker, are of two kinds. One, with the regular lamellae system surrounding it, and the other, the so-called Volkmann's canals, containing the perforating vessels of Von Ebner, which have no surrounding lamellae, but simply penetrate through the layers of bone. Volkmann's canals are present in all tubular bones in old and young. While especially marked in the outer basal lamellae, they occur also in the interstitial leaflets and in the inner chief lamellae as well as in the periosteal layers of the skull bone. Here their number is variable. They run partly transversely or obliquely, and partly longitudinally through the lamellae. Many of these canals open in the outer or inner surfaces of the substantia (compact substance) and also here and there in the Haversian canals, and usually form altogether a wide-meshed irregular net-work. In structure they are sometimes smooth and sometimes furnished with dilatations and angles projecting in and out in profile. The widest has a diameter of 100 micrometers or more, the narrowest not more than 10 or 20 micrometers, and there are still narrower ones which are altogether obliterated, appearing like rings or circularly formed structures without any lumen, or like those far from rare obliterated true Haversian canals first described by Tomes and de Morgan. The contents of the Volkmann canal are the same as the Haversian canal.

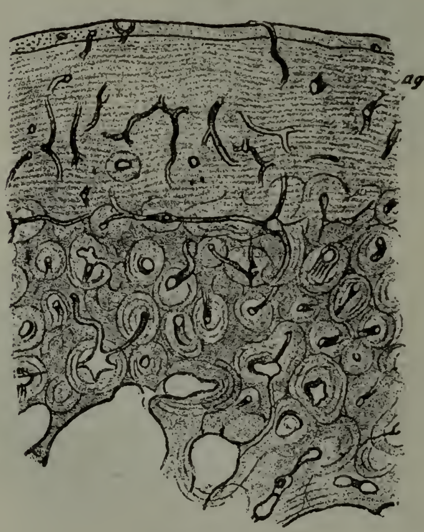


FIGURE 170
Microscopic section of bone showing blood vessels of Von Ebner (Kolliker).

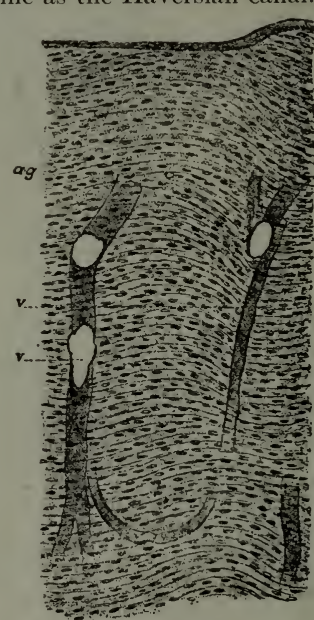


FIGURE 171
Section of bone (higher magnification) showing blood vessels of Von Ebner (Kolliker).

Fig. 170 is a cross section of the medulla of a calcified human humerus, slightly enlarged. The outer lamellae contain a large number of Volkmann's canals running longitudinally and transversely and extending through the outer plate of bone into the periosteum. Fig. 171, the cross section of the section seen in Fig. 170, shows these canals more highly magnified. The Haversian canals are large round spaces, Fig. 172 con-

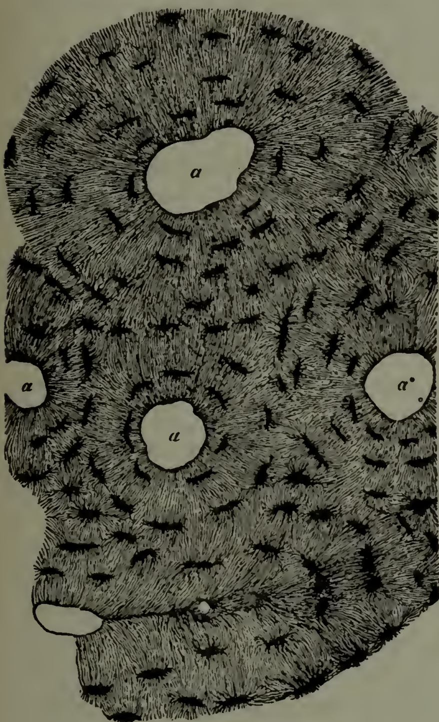


FIGURE 172
Transverse section of the humerus magnified 350 times (Gray).

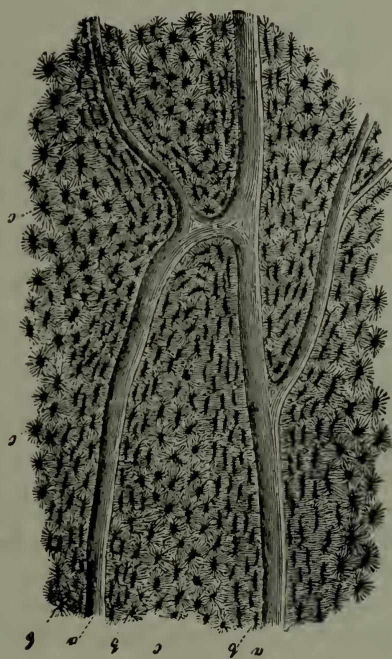


FIGURE 173
Longitudinal section of bone magnified 100 times (Gray).

taining a single artery and vein. The fine hair-like spaces running from these large spaces are canaliculi. The dark spots encirling each Haversian canal are the lacunae. The canaliculi run from one lacuna to another, or into an Haversian canal, or anastomose with each other. The lacunae seem to be about uniformly distributed throughout the bone. The spaces between the lacunae and canaliculi are filled with lime salts.

A longitudinal section of bone (Fig. 173) is similar in appearance to the cross section. Instead of the lacunae being arranged in rows around the Haversian canals, they are parallel. It will be noticed that the Haver-

sian canals run in different directions and communicate with each other at certain intervals. The foregoing covers essentially the minute anatomy of the alveolar process.

Summary

The alveolar processes are distinct and separate structures from the maxillary bones, being transitory, provisional bones.

They do not appear until the first teeth are erupted, moulding themselves around the roots.

The process consists of an outer and inner plate, joined at intervals by calcellous septa, the inner being the thicker, because the absorption of the process is slower than the growth of the jaw.

As the jaws grow smaller in evolution, the teeth grow smaller in diameter and longer in root, producing a higher arch.

The teeth are fixed in their alveolar sockets by gomphosis, resembling a nail in a board of wood.

The teeth act as foreign bodies to the alveolar process, rendering the latter physiologic end-organs.

Under the influence of an unstable nervous system, or trauma, or inflammation, an extra deposition of calcium salts occurs, making the bone dense and hard, retarding, in children, the eruption of the second teeth.

Or, under similar influences, the alveolar process may hypertrophy, crowding out some of the teeth and narrowing the arch.

Correction by pressure, under these circumstances, is to be condemned, also attempts to widen the arch without extraction.

Microscopically, the alveolar process contains two types of Haversian canals—(1) with regular lamellae systems surrounding it, (2) the so-called Volkmann's canals, containing the perforating vessels of Von Ebner and no surrounding lamellae.

Chapter XX

INTERSTITIAL GINGIVITIS

It is necessary now to consider developmental pathology of the alveolar process. In the evolution of the head, face, jaws and teeth, the alveolar process, including the jaws, grows smaller and the alveolar process changes its shape. It, therefore, must be considered a transitory structure. In the preceding chapter it was shown that the alveolar process is a bony structure intended only for the purpose of holding the teeth in position. This bony structure is absorbed when the teeth are removed and is therefore a transitory structure. In phylogeny, all vertebrates which have teeth, namely, fish, batrachians, reptiles and mammals, shed their teeth in some manner.

In Some Fish the teeth are constantly shed and renewed during the whole course of their lives. In fish which have compound teeth, as well as in those which have apparently permanent teeth, as in the saw of the sawfish, the wear of the surface is made up by a constant growing of the tooth from its base. When the teeth are implanted in the alveoli, they are generally succeeded by others in the vertical direction, as in Sargus, but in others they succeed one another, side by side, as in sharks, rays and skates. Generally, there are more than one tooth growing which are in various stages of development, and destined to replace the one in function.

In the Manatee the incisors are rudimentary, concealed beneath the horny oral plate and disappearing before maturity. Molars 11/11 but rarely more than 6/6 present at one time. These teeth succeed each other from before backwards, as in the elephant, the anterior teeth falling before the posterior teeth come into use.

In the Dugong besides the large tusk-like incisors, there is, in the young, a second small deciduous incisor on each side above. At this age there are also beneath the horny plate which covers the anterior portion of the mandible four pairs of slender teeth in wide alveolar depressions; these become absorbed before the animal reaches maturity. The molars are usually 5/5, sometimes 6/6 altogether, but not all in place at once, as the first falls before the last rises above the gums.

In Snakes there is a perpetual succession of teeth. This holds good for reptiles and all amphibians that have teeth.

In Crocodiles as the teeth wear out or are lost they are replaced by others, formed on the inner side of those which they are destined to succeed. This process appears to go on indefinitely throughout life.

In Elephants six teeth are successively developed, the hinder-most one being much more complex than the anterior ones.

In Man's Ontogeny it would be strange if he did not retain some of the phylogenetic peculiarities of the lower vertebrates in tooth development in relation to the alveolar process. Man has two sets of teeth. He sheds the first after it has performed its function, and a new set takes its place. As soon as the alveolar process has developed about the teeth, and man has attained his growth, a low form of inflammation is present to set up absorption. I have called this process osteomalacia, or senile absorption. This form of absorption will continue until the teeth loosen and drop out if man lives long enough and continues in a fairly normal state of health. This process is atavistic. In this respect, also, we have a transitory structure. The alveolar process, therefore, may be considered a doubly transitory structure.

The Alveolar Process as an End Organ. I have called the alveoar process an end organ. My reason for doing this is that the tooth, so far as the process is concerned, is a foreign body. The arteries, vessels of Von Ebner and especially the nerves pass through the bony process, in a wavy manner and stop at the root of the tooth.

There are other end organs in the body, chief of which are the kidneys, the eye and the brain. Physicians claim, and rightly, that because these are end organs they are more easily involved in disease and are often the determining factors of kidney lesions. Alfred C. Croftan says, "It is not surprising to find that particularly those organs that are supplied by end arteries are chiefly involved, for in them vascular disturbances must first produce nutritional derangement. Chief among the organs supplied by end arteries are, precisely, the kidneys, the retina and the brain, and I think this explains the frequent involvement of the kidneys, eyes and brain in Bright's disease. The fact that the retina and the brain are often found injured before the kidneys, that cases of Bright's disease run their fatal course occasionally with practically no renal changes, but with serious apoplectiform brain lesions and retinitis, bears out this conception and constitutes a valid argument against the common belief that the nephritis is the primary event and the determining phenomenon of the disease."

A marked difference exists between the kidney, eye and brain as end organs and the alveolar process as an end organ. This difference is the important point in the study of interstitial gingivitis. End arteries running into the kidney, eye and brain, owing to the soft nature of these tissues, are given a chance to expand and recover, permitting, in a measure, the blood to flow more easily, thus prolonging the tendency to disease, or allowing the tissues, under favorable conditions to recover. On the other hand, blood vessels extending throughout the alveolar process in a tortuous

manner cannot expand, and as a result, blood charged with toxins and subject to cardio-vascular changes immediately sets up irritation and inflammation which results in dilatation, bone absorption and arterial degeneration. These changes, therefore, will occur much earlier in the alveolar process than in other end organs.

The transitory nature of the alveolar process, especially as an end organ, makes it exceedingly sensitive to systemic changes and disease. The sensitiveness of this structure to autotoxic states is easily demonstrated as people advance in years. At the fifth period of stress (about forty-five) the excretory organs weaken. The toxic elements of the body are not carried off as freely as formerly. These circulate in the blood and accumulate in the alveolar process, setting up irritation and inflammation. Absorption of the alveolar process gradually takes place. People enjoying apparently good health will, as they advance in years, note the absorption of the alveolar process and the exposure of the roots of the teeth. How much more readily will absorption take place when the function of any one of the eliminating organs be involved, such as constipation, asthma, skin affections or kidney lesions.

Causes of Interstitial Gingivitis. Diseases which attack the alveolar process and cause interstitial gingivitis may be classified under two heads. First, *infectious diseases*, such as syphilis, tuberculosis, actinomycosis, anthrax, spirilla and gonococci, etc. Second, *irritations*, those of a local and constitutional nature. Infectious diseases, as compared with those due to local and constitutional irritation, are not so common. Each infection, however, possesses its own characteristic picture and cannot be confused with the irritations or with other infections.

The Irritations of a Local Nature which produce interstitial gingivitis are, the eruption of the teeth; the movement of the teeth by mechanical appliances for the purpose of correcting irregularities, for acquiring space for filling teeth, crown and bridgework; ill-fitting artificial dentures; heat under artificial dentures; ragged edges of fillings; collections of food and other foreign material such as tartar, calcic deposits, etc.; excessive use of brushes; toothpicks and all other local irritations.

The Constitutional Irritations are drug and metal poison and autointoxication, due to disease and faulty metabolism.

The bone, at the gingival border, is usually the first involved because it is thinner and because it is farthest remote in artery and nerve supply, and gradual absorption takes place toward the end of the root. This, however, is not always the case. Occasionally, the irritation is located in the bone at the middle or apical end of the root causing interstitial gingivitis and absorption of bone at these localities. These irritations may be caused by gases passing out of the root at the apical end, due to a

dead pulp or to an accumulation of toxins in the blood, following the arteries in these localities and other causes.

Scurvy produces the same train of symptoms as the metals, through its disturbance of metabolism.

The Jaws of the Hereditarily Defective, whether the defect be in the direction of advance or degeneracy, are fruitful soil for the development of interstitial gingivitis. In the mouths of the congenital deaf, dumb, blind, feeble-minded and delinquent children, interstitial gingivitis attacks the alveolar process before the osseous system has reached its growth. Here, as a consequence of trophic change, metabolic action and premature senility, interstitial gingivitis may occur in connection with the first set of teeth at two years or any period thereafter. This may be called juvenile interstitial gingivitis. Regulating teeth and senile absorption are predisposing causes to future interstitial gingivitis.

Interstitial Gingivitis in Animals. Interstitial gingivitis of the alveolar process is almost as common among domestic and wild animals in captivity as it is in man. Wild animals in zoologic gardens without proper exercise, in close confinement, with impure air, and fed upon too easily digested food, naturally acquire autointoxication, resulting in interstitial gingivitis. This is particularly noticeable in monkeys, whose

Figure 174

A monkey skull showing absorption of the alveolar process (original). The right central and left lateral have dropped out. The alveolar process is absorbed so that all teeth are loose.

changes of environment render them very susceptible to disease, especially to tuberculosis. Trophic changes and impaired metabolism are thereby so impressed upon monkeys that not infrequently the first teeth become prematurely loose and drop out. Fig. 174 is the skull of a monkey who died, aged one year, of tuberculosis. Absorption of the alveolar process is the result of tubercular autointoxication. The right superior and inferior central and lateral incisors have loosened and dropped out. The roots of all the teeth are exposed to a marked extent. The teeth could be removed with the fingers.

FIGURE 175
The mouth of a Scotch terrier (original). All the teeth on the right side, posterior to the cuspids have dropped out. The other teeth are loose.

The horse and cow are prone to this disease. Cattle return to the stable after the summer's sojourn in the field and then, being fed upon a changed diet without the usual exercise of cutting grass with their teeth, undergo a reaction in their jaws and interstitial gingivitis results. "Cribbing" of the horse is a marked illustration of the uneasy feeling resultant on this reaction. Cattle fed upon brewers' grain and slops suffer most.

Dogs afford the best opportunity, however, for studying interstitial gingivitis among animals. An examination of dogs in one hospital showed that every one had interstitial gingivitis in all degrees from its inception to the loss of all the teeth. The number of dogs observed was twenty-seven. The outer plate of bone was absorbed, the roots entirely exposed, pus was oozing from around them and the mucous membrane was badly inflamed. It should be remembered that the jaw of the dog, like the jaw of man, is undergoing considerable variation. Like man, the dog, having put himself under new social conditions, so to speak, is varying greatly both as to brain, skull and jaw from his wolf-like ancestor. As he is under the protection of man, the struggle for existence is less intense than in the wild state, and consequently, there is less occasion, even for fighting purposes, for the use of his jaws and teeth. Independently of conditions of this type, many of the dogs suffered from constitutional disorders. Eight had skin diseases which, in the dog, are more likely to produce obvious constitutional defects than in man. Some were old and blind. Some had been injured and were under treatment for wounds; some were suffering from rachitis, nervous diseases, and were over-bred. Others were constipated, or had germ type diarrhoea. One had kidney inflammation and bronchitis with high fever. In short, these dogs, being house dogs, presented most of the constitutional diseases to which man is liable.

The mouth of a Scotch terrier is shown in Fig. 175. The teeth on the upper and lower jaw had been removed with the fingers from the cuspids back. The cuspids and incisors were quite loose. There are large deposits of tartar. The gums and alveolar process have been absorbed nearly one half the length of the roots of the remaining teeth. Fig. 176 shows the teeth

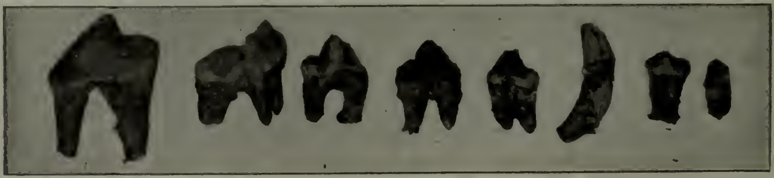


FIGURE 176
Teeth of dog removed by fingers due to interstitial gingivitis (original).

covered with calcic deposits the entire length of the root which I removed from the mouth of another dog. These teeth were removed by the fingers from a dog obtained for scientific study.

Twenty-five per cent of roving dogs at four years of age have the disease. Eighty per cent of eight-year-old, at least ninety-five per cent of twelve-year-old and all fourteen-year-old dogs have the disease. House dogs suffer to a marked extent with interstitial gingivitis of the alveolar process, no doubt from being trained to house cleanliness which interferes with natural excretion, causing autointoxication and odor.

Fig. 177 is that of a physician thirty-six years of age. Fig. 178 is that of a physician thirty-eight years of age. Both these gentlemen are appar-

FIGURE 177
Cast showing absorption of the alveolar process due to interstitial gingivitis (original).

FIGURE 178
Cast showing absorption of the alveolar process due to interstitial gingivitis (original).

ently in the best of health. One has slight indigestion, which is the cause of absorption; the other took calomel for malaria, fifteen years previous, and became salivated. This is a predisposing cause. In each case, all the teeth are involved both inside and out, some are loose. There is no pus in either case and the gums are apparently healthy.

In consulting the literature upon this subject, I find that absorption of the alveolar process and recession of the gums has been attributed, by many authors, to the severe use of the tooth brush. There are certain conditions in which the tooth brush will assist absorption of the alveolar process. These are easily observed. I refer to the position of the cuspid teeth, where they stand prominently. The bone over the roots of the teeth in these instances is as thin as tissue paper, and the slightest friction

will set up a low form of inflammation, which, in turn, produces absorption of the bone, exposing the root. The brush never, however, produces senile atrophy in other parts of the mouth except under similar conditions.

The absorption of the alveolar process in interstitial gingivitis is not always uniform, as sometimes only one or two teeth are involved. Local conditions, however, modify the extent of the disease. In most instances, there is a gradual absorption of bone about all the teeth.

The pathology of interstitial gingivitis is not unlike osteomalacia of the pelvis, spine or other bones of the body, as demonstrated by Hektoen. Halisteresis is the principal form of absorption. Perforating canal absorption, described by Volkmann, is common, passing through fragments of bone. Lacunar absorption is also present and osteoclasts are frequently found. Howship's lacunae containing osteoclasts are found in the margin of irregular islands of bone. This form of absorption, while nearly always present, is not so important as halisteresis, being much slower in its action. New osteoid tissue is rarely seen. This absorption is a natural destruction and the bone is never reproduced.

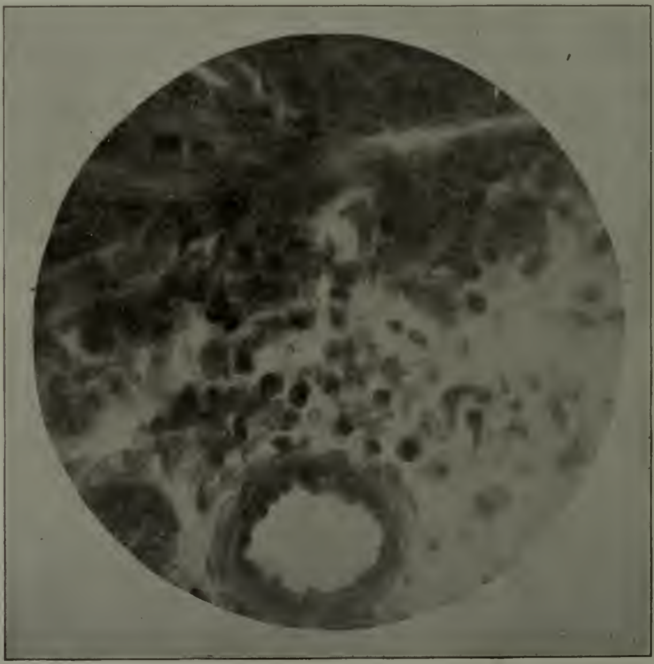


Figure 179

Microscopic illustration of the first stage of inflammation in jaw of dog (original). Shows thickening of arteries.

To demonstrate the effect of drug poisons and other irritants upon the alveolar process, a series of experiments have been conducted for two decades on animals and human. These consisted of the examination of the jaws of dogs with interstitial gingivitis due to different diseases; to saturating the system of healthy dogs with mercury; the examination of the jaws of monkeys who died of tuberculosis; the examination of the jaws of cows and horses suffering with interstitial gingivitis due to faulty metabolism; and the examination of human jaws with diseases resultant from tuberculosis, syphilis, mercury and lead poisoning and scurvy. A series of experiments were conducted, extending over one winter, on dogs whose teeth I moved in an analogous manner to the correction of irregularities of the teeth in the human. The structures were removed and prepared in the usual way for the microscope.

Fig. 179 shows round cell infiltration and inflammation extending to the inner coat of the blood vessel, and also plasma mass cells. This inflammatory process was brought about at the gingival border of the alveolar process by administering mercury to a young, healthy dog. This illustration shows the first stage of the inflammatory process. Quite a thickening of the arterial wall is observed.

The following illustration (Fig. 180) represents the alveolar process of a man forty-eight years of age, killed in an accident. The illustration

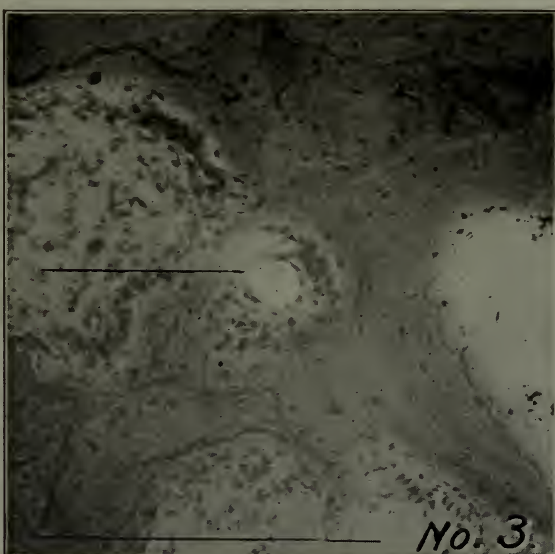


FIGURE 180
Four centers of halisteresis absorption beginning at Haversian canals in alveolar process of man (original).

shows four areas of bone absorption called halisteresis (melting away of bone substance). The waste products become irritants in the blood stream and set up a low form of inflammation in the Haversian canals. The inflammation thus set up produces rapid absorption. Each of these local areas enlarges until they join. In this way, large areas of absorbed bone are produced. In the center of this illustration is seen an Haversian canal with active inflammation around it. The bone is absorbed. The inflammatory process is in the trabeculae or fibrous part of the bone. Adjoining is a large area with bone absorption, but the fibrous part of bone remains unbroken. The inflammatory process is seen throughout. At the lower border of the picture are two large areas of bone absorption. The trabeculae are seen with round-celled infiltration, while the center is destroyed. At the right, absorption and destruction of the trabeculae are seen to the margin of the bone.

Fig. 181 shows halisteresis at two Haversian canals. One area is much larger than the other. Both have met and the area of inflammation

FIGURE 181.
Two areas of halisteresis absorption showing trabeculae with round cell inflammation (original).

will be much enlarged. The trabeculae are present and filled with round-celled infiltration.

Fig. 182 illustrates a large area of absorption, with destruction of the fibrous tissue to a larger extent. Around the border is seen a small amount of inflamed fibrous tissue. An artery, once an Haversian canal, is also seen. About the large area are also seen three Haversian canals with the inflammatory process just beginning.

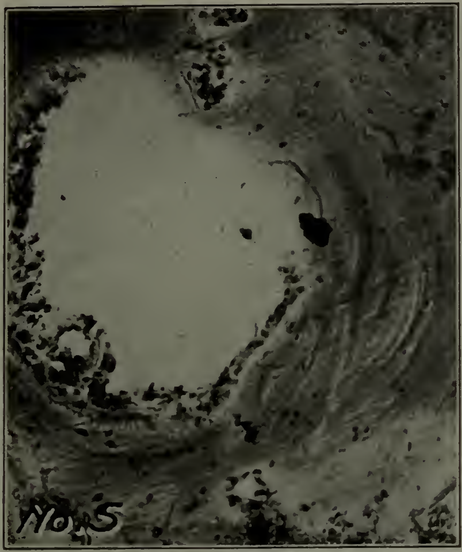


FIGURE 182
Three areas of inflammation at Haversian canals (original). In the lower and larger area, the trabeculae have been destroyed; only a slight amount with round cell infiltration is noticed at the border. When the trabeculae is destroyed in large areas, the bone is never reproduced.

FIGURE 183
Shows four areas of halisteresis absorption with Volkmann canal absorption proceeding between the area (original).

Figure 184
Lacunar or osteoclast absorption of the alveolar process (original).

Figure 185
Three forms of bone absorption between bicuspid roots (original).

Fig. 183 shows four centers of absorption at Haversian canals. Through the picture may be seen dark lines running in all directions. These are vessels of Von Ebner, through which Volkmann's canal absorption takes place. A beautiful illustration of this is seen in the canal running from one large area of absorption to the other.

Fig. 184 shows the third form of bone absorption—lacunae or osteoclast absorption. Here a large area of bone is destroyed by these large cells.

Fig. 185 is a low power, showing the distribution of the alveolar process between the roots of two teeth. Very little of the bone remains. When the trabeculae or fibrous tissue is destroyed in large areas, and especially in transitory structures, it is rarely restored.

In the different forms of bone absorption, especially halisteresis and Volkmann's perforating canal absorption, islands of bone are seen in the fibrous remains of the alveolar process (Fig. 186 and 187). These spiculae

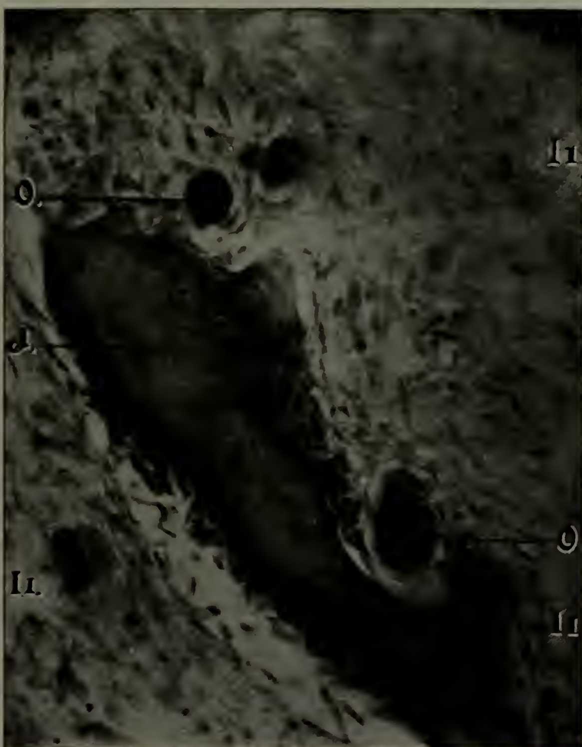


FIGURE 186
Islands of alveolar process in dog due to two forms of bone absorption (original). *J*, island of alveolar process; *o*, lacunar absorption; *i*, halisteresis absorption with trabeculae in position.

of bone are sometimes very annoying and cause considerable trouble. Occasionally, they produce so much irritation that an abscess will form, discharging the piece of bone through a fistulous opening. Again, the bone will become exfoliated by means of absorption, without abscess.

In the earlier symptoms of interstitial gingivitis, erosion, abrasion, discoloration and tooth softening, due to faulty metabolism and autointox-

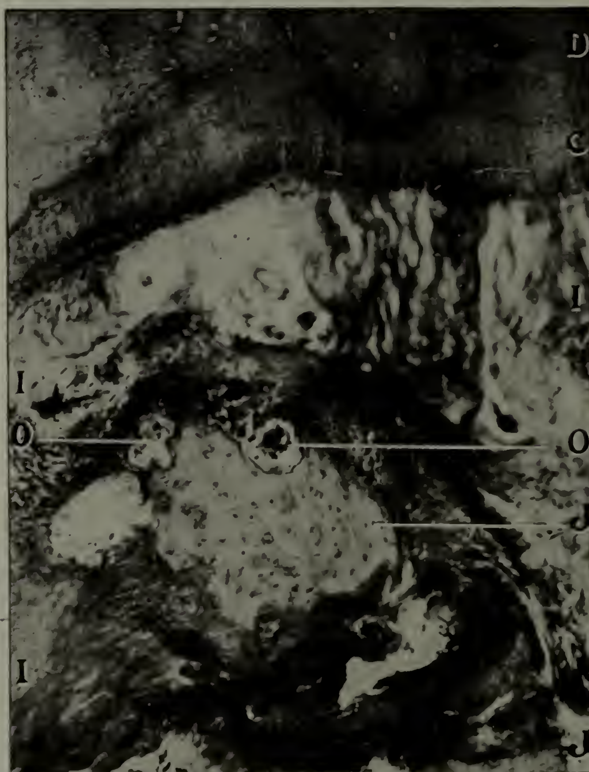


Figure 187
Cross section of tooth alveolar process and peridental membrane in man (original). *d*, dentin; *c*, cementum; *i*, peridental membrane and trabeculae; *j*, island of aveolar process; *o*, lacunar absorption.

ication, there are no symptoms of blood pressure. The transitory nature of the alveolar process and tooth pulp, both being end organs, make them more susceptible to blood changes than other structures of the body. These tissues, therefore, may become diseased for many years before other structures of the body become involved. Later, however, when the

more serious symptoms result, such as renal insufficiency, acute and chronic nephritis and changes in heart and arteries, blood pressure is observed.

To ascertain the blood pressure in patients suffering with interstitial gingivitis, I used Cook's modification of the Riva Rocci Sphygonomanometer, this instrument being best adapted for my convenience and exceedingly simple. The patients ranged from twenty-seven to sixty-seven years of age. With this instrument, the normal adult fĕmale arterial blood pressure is 115 to 125 mm.; adult male, 125 to 135 mm.

In twenty-six females there were three who ranged between 115 mm. Hg. and 125 mm. Hg. and, therefore, normal. Three ranged below 115 mm. Hg. and twenty from 133 mm. Hg. to 180 mm. Hg.

In twenty-four males there were eight who ranged between 125 mm. Hg. and 135 mm. Hg. and, therefore, normal. Three ranged below 125 mm. Hg., and thirteen from 133 mm. Hg. and 160 mm. Hg.

When we consider that thirteen of these patients were under forty-five years of age, the high blood pressure is remarkable.

I have been unable to demonstrate whether the interstitial gingivitis is accelerated directly because of the poisons circulating in the blood vessels, causing high blood pressure by their action upon the heart, or because of their action upon the vasomotor nerve governing the heart or blood vessels, or both.

Summary

All phylogenetic types of vertebrates shed their teeth in some manner and renew them—the lower types more or less continuously throughout life.

Man sheds his first (temporary) set and develops his second (permanent) teeth.

As soon as these are developed, an inflammatory process sets in around the roots, called by the author osteomalacia, which will eventually loosen the teeth and allow them to drop out. In this respect, the alveolar process is a doubly transitory structure.

The alveolar process is an end organ similar to the eyes, brain and kidneys, but with this important difference, that its substance is hard, allowing no expansion of terminal arteries, and making the alveolar process peculiarly sensitive to change and disease, which bring about an inflammation-absorption process known as interstitial gingivitis.

Causes may be classified into infections and irritations, each manifesting its own symptom—complex.

In hereditarily defective children the absorption begins before ossifica-

tion, thus producing interstitial gingivitis of temporary teeth—juvenile gingivitis.

Domestic and caged animals suffer from gingivitis.

The pathology consists chiefly of halisteresis, also of Volkmann's perforating absorption.

Chapter XXI

ENDARTERITIS OBLITERANS AND CALCIC DEPOSITS

ONE of the most interesting pathologic processes which almost always develops in connection with interstitial gingivitis is that of endarteritis obliterans. The alveolar process, being a doubly transitory structure and an end organ, the arteries in their tortuous position are unusually susceptible to this disease. The poisons circulate in the blood, accumulate and set up irritation and inflammation of the coats of the vessels which become thickened and obliterated.

Pathology. Endarteritis is an inflammation of the intima or internal coat of the arteries, generally of a chronic type. Other coats of the arteries may become involved and also show a thickening. Its pathogeny is as follows: In direct contact with the blood streams is the endothelium (a layer of flattened cells); next is the tunica intima, composed of elastic fibers arranged longitudinally; next comes the middle coat, composed of muscular fibers arranged transversely. The outer coat consists of longitudinal connective tissue, which contains the vasa vasorum. In the capillaries the intima lies in immediate contact with the surrounding tissues, or is accompanied by a rudimentary adventitia. In other words, the walls of the capillaries consist of almost nothing but the intima. The capillaries have a certain contractility; they contract or dilate without muscular fibers. The veins probably also exhibit a certain amount of contraction and dilation from irritability of the intima. Each coat of the arteries takes on a special type of inflammation.

The causes of endarteritis are numerous. Inflammation of the intima of the blood vessels may be due to irritation from without or within. When it occurs from without, any local irritation will set up an inflammation which may extend to the outer coats of the capillaries. This produces a marked increase of blood. The vasa vasorum become swollen, the white blood corpuscles crowd into the terminal capillaries and migrate into the extra vascular space. Rapid proliferation of the round cell elements takes place. The walls of the vessels become thickened. Owing to the projecting intervals of the intima, the caliber of the blood vessels diminishes (Fig. 188).

Causes. Irritation occurring from within results either from trophic changes in the system or from direct irritation from toxemias, or may come from both interdependently. Under these circumstances a germ disease or other toxins may have an affinity for a certain organ, tissue or part, and produce irritation in the capillaries in a distinct part of the body; or the capillaries through the entire body may become involved. Thus,

in typhoid fever, Peyer's glands in the intestine become involved; in scarlet fever, the skin or kidney; in malaria, the liver and spleen; in Bright's disease, the kidney; while in mercurial and lead poisoning and scurvy, the mucous membrane and especially the gums become diseased. In many of these conditions, however, before the tissue already irritated

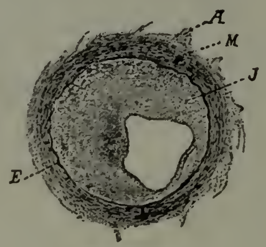


FIGURE 188
Endarteritis obliterans (Kaufman). *A*, adventitia; *e*, elastic tissue between middle coat and intima; *m*, muscular; *j*, thickened intima.

becomes involved, the nervous system may already have become affected from other causes, such as locomotor ataxia, traumatic injuries to the spine, paretic dementia, cerebral paralysis, neuroticism and degeneracy, and last but not least, stomach neurasthenia. The poison in the blood, together with the diseased peripheral nerves. produces irritation and inflammation of the inner coat of the capillaries. If this irritation does not disappear soon after its inception, the inflammation tends to affect the other coats of the blood vessels. Under certain conditions, however, endarteritis may never involve the other coats of the vessels. When irritation of the inner coat of the capillaries takes place proliferation of the endothelium occurs. This inflammatory growth tends to obstruct the lumen of the vessel. The media may likewise become thickened by an increased connective tissue. The capillaries become obstructed and finally obliterated, which eventually impedes the circulation. Fig. 189 shows such a condition in a case of scurvy.

Irritation may be of less intensity but greater duration, as in syphilis, tuberculosis, scurvy, mercurialism, plumbism, etc., and the results are then effected slowly. Proliferation of subendothelial connective tissue gradually increases until it reaches its limit (endarteritis obliterans). This influence of the proliferation is exerted in addition to that of the round-cell infiltration about the structure.

The recent studies of Hektoen on meningeal tuberculosis demonstrate that tubercle bacilli may penetrate the unbroken endothelial layers of the vessel and stimulate proliferation of the subendothelial connective tissue. An internal irritant, such as may be produced in the course of any infectious

disease or from suboxidation, probably acts upon the endothelium of the walls of the smaller blood vessels in such a way as to permit the escape through the walls, first of serum, and then of leucocytes, the latter infecting and surrounding the vessels. The effect of the chronic endarteritis is to

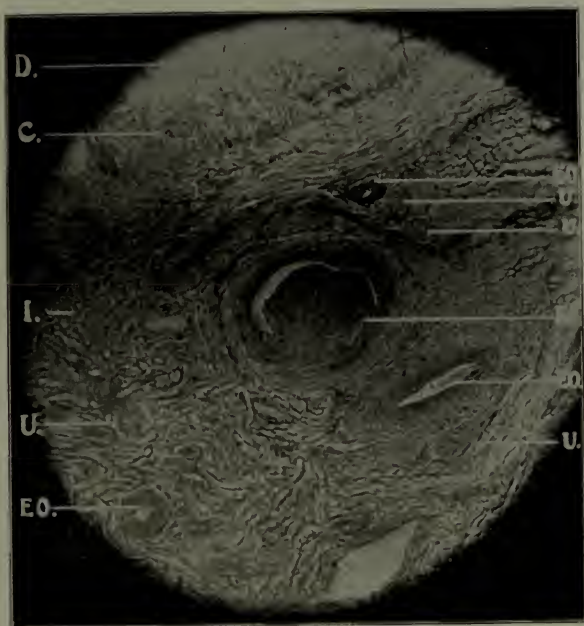


FIGURE 189
Endarteritis obliterans. Scurvy in man (original). *C*, cementum; *d*, dentin; *i*, peridental membrane; *u*, nerve tissue; *eo*, endarteritis obliterans.

check the blood supply to the gum and alveolar tissue. Mercury, lead and other poisons circulating through the blood are forced to remain, hence the discoloration of tissue along the gum margin. Interstitial gingivitis, resulting in a slow disturbance of nutrition, produces overgrowth of connective tissue. In all cases of chronic interstitial gingivitis, as shown in the illustration, are the blood vessels thus involved.

Among the predisposing influences which cause this disease are syphilis, tuberculosis, mercurialism, plumbism, brass poisoning, lithemia, nephritis, gout, rheumatism, alcoholism, scurvy, nervous diseases, pregnancy and old age. Under certain conditions of the system any and all diseases which tend to lower the vitality, producing anaemia, will assist in producing this disease. The direct cause may be resultant overstrain of the blood vessels.

On administration of drugs, especially mercury or lead, to healthy young dogs, inflammation of the alveolar process with diseased arterial

Figure 190
Endarteritis obliterans in pregnancy (original). The two light spots are centers of arteries nearly obliterated.

Figure 191
Endarteritis obliterans in alveolar process of dog (original). *n*, trabeculae remaining after absorption of bone; *eo*, endarteritis obliterans.

walls is seen at the end of a month or six weeks. Fig. 179 shows the commencement of the thickening of the intima in a dog. The coats of the arteries are well defined, and the inflammatory process has just begun. Examination of the alveolar process of animals or human beings suffering from disease in which the eliminating organs are not throwing off effete matter, especially in syphilitic, tuberculous and scorbutic patients, easily reveals this morbid state.

Fig. 190 is a poor illustration of the disease in pregnancy. If such patients are degenerates the process will be exaggerated.

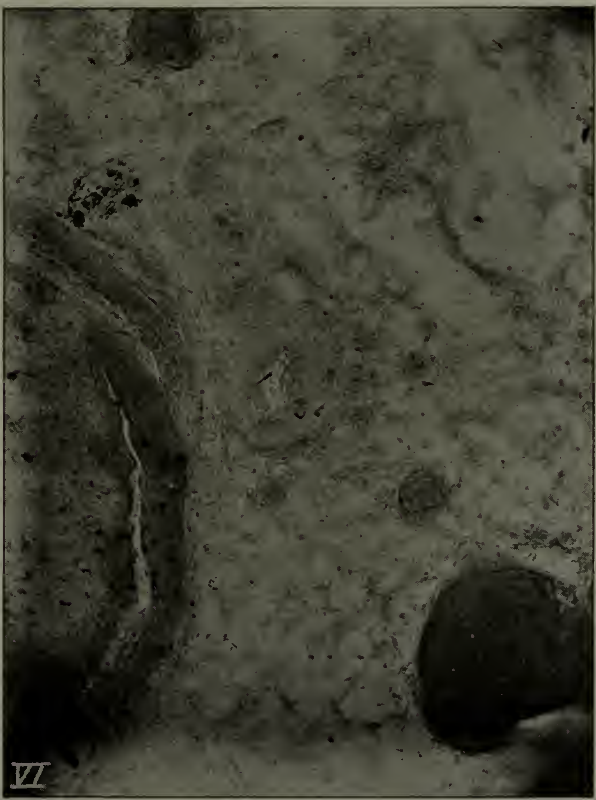


FIGURE 192

Endarteritis obliterans in a tuberculous monkey (original). At the left may be seen an artery cut lengthwise almost obliterated. In the center an artery cut crosswise almost obliterated. Just below are two small obliterated arteries. At the right lower corner may be seen a large obliterated artery. In this picture the bone has entirely absorbed leaving the trabeculae intact.

Fig. 191 illustrates endarteritis obliterans in the artery of a dog with interstitial gingivitis.

Fig. 192 is from the alveolar process of a tuberculous monkey.

Fig. 193 illustrates the closing of three arteries from mercurial poisoning.

Fig. 194 shows endarteritis obliterans with arterial-coat hypertrophy in interstitial gingivitis from lead poisoning.

Fig. 195 shows hypertrophy and endarteritis obliterans in interstitial gingivitis from diabetes mellitus.

FIGURE 193

Endarteritis obliterans in mercurial poisoning (original). Three arteries may be seen nearly obliterated. The trabeculae with round cell infiltration is easily distinguished.

Fig. 196 illustrates hypertrophy of three arteries in a syphilitic.

No structure affords such a favorable opportunity for the study of endarteritis obliterans as the alveolar process in animals and human, since it can be obtained in quantities at all times and under all conditions. It may be produced in healthy animals by the internal administration of drugs, metals and other poisons.

FIGURE 194
Endarteritis obliterans in diabetes mellitus (original). In the upper right hand corner, the root of the tooth is seen. The fibrous tissue of the peridental membrane and the trabeculae are continuous with round cell infiltration.

FIGURE 195
Endarteritis obliterans in diabetes mellitus (original). The bone has entirely absorbed.

Calcic Deposits

From what has been said and demonstrated by the illustrations, it would seem that in those cases where interstitial gingivitis and endarteritis obliterans have occurred, the old theory that serumal deposits are deposited from the blood vessels would be faulty teaching. Since there is no circulation in the blood, deposits could not take place from this source.

Again, if the theory were tenable, such large deposits as found on the roots of some teeth could not arise from the blood stream.

After years of study upon animals and human in regard to those deposits, I concluded these deposits did not come direct from the blood,

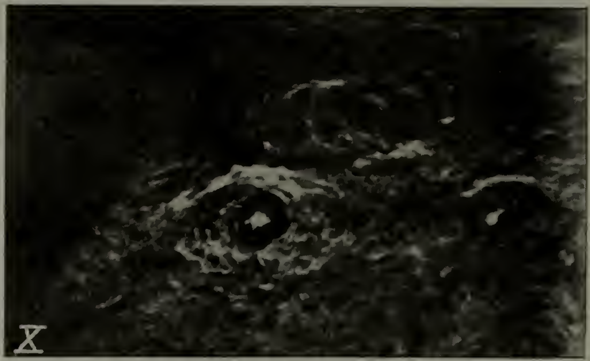


FIGURE 196
Endarteritis obliterans in a syphilitic (original).

as advocated by Dr. Ingersoll, but represent the residue of the absorbed alveolar process about the root (Fig. 197) of the tooth. This material, floating in fluids (saliva, pus, etc.,), is attracted to the root of the tooth in a similar way to the formation of stalactites or stalagmites in a cave. Sometimes only a small amount is deposited at some particular locality on the root, showing that poisons are circulating in only a few arteries and interstitial gingivitis has taken place in a small area. Absorption of the alveolar process, however, has occurred, and the debris has collected at that particular spot. Again, the entire side of the root may be involved or only the apical end of the root. The deposit is always circumscribed in the area of inflammation. The method of testing the calcium salts in the fluids about the absorbed alveolar process and roots of the teeth is very simple.

Take the contents of a pocket and dissolve it in hydrochloric acid, add three times its bulk of water, to this add ammonia, which will precipitate the phosphate and the calcium. The same results may be obtained

by rinsing a freshly extracted tooth of a pyorrhoea case in cold water. With a stiff brush remove the accumulation and place it in a test tube, add hydrochloric acid and more water if necessary. To this add a solution of ammonia and the lime salts are precipitated.

FIGURE 197
Calcic deposits from absorbed alveolar process upon the palatine root of a molar tooth (original).

Roots of teeth that have become entirely denuded of peridental membrane and bathed in pus accumulate large quantities of calcic deposits direct from the destroyed alveolar process.

Summary

The tortuous end-arteries of the alveolar processes are peculiarly susceptible to endarteritis, a chronic productive inflammation of the internal coat. The causes may operate from within or from without.

Internal causes include trophic changes and toxins. External causes comprise all forms of local irritation, operating through the external to the internal coat. Predisposing influences are constitutional diseases, drugs, heredity and nervous instability.

Calcic deposits in endarteritis and gingivitis represent the debris of the partly absorbed alveolar processes about the roots. Their character as calcium salts can be determined by dissolving in hydrochloric acid and precipitating the calcium and phosphates with ammonia.

Chapter XXII

PUS INFECTION

IN the chapter on "Interstitial Gingivitis," it was shown how inflammation of the alveolar process might be caused by infection, by mechanical or local irritation and by substances within the organism without the aid of infection, namely irritants in the blood stream. In the last named group, the irritations may be due to drug or metal poison, poisonous gases or the result of metabolic disturbance whereby the products of metabolism are deposited in the arteries and capillaries in the alveolar process. Each irritant may set up interstitial gingivitis in a different part of the alveolar process, and thus be confined to that particular locality. On the other hand, the inflammation may spread to the neighboring tissue and the entire alveolar process may become involved.

When the inflammatory exudate is made up of leucocytes, there is produced within the tissue small round-cell infiltration which becomes so thick as to obscure the tissue. When the leucocytes are in large numbers upon the surface of the mucous membrane about the cervical margin of the alveolar process, their appearance on the inflamed surface is that of a white fluid which is called pus. This leads to a superficial loss of substance and is known as ulceration or purulent catarrh. When the leucocytes collect in arge numbers, within the tissue, and are followed by liquefaction and dissolution of the tissue, it is called an abscess. The alveolar process may be destroyed by interstitial gingivitis; it is only necessary there should be a low form of inflammation taking place in and about the arteries and capillaries to produce absorption of bone. This is what occurs, in fully ninety per cent of patients. In the other ten per cent, the infection or irritation is more severe and the inflammatory exudate is made up of leucocytes in which the small round-cell inflammation is violent causing either pyorrhoea alveolaris, dento-alveolar abscess or peridental abscess, according to the nature of the infection and its location. Having outlined the process of pus infection and formation, let us follow the course of the different inflammations as they actually occur in practice. First of all, however, note that the inflammatory process, interstitial gingivitis, always precedes pus infection. The universal custom of calling a disease of the alveolar process pyorrhoea alveolaris is untenable and misleading.

Pyorrhoea Alveolaris begins with a local irritation from any cause which sets up inflammation (interstitial gingivitis) at the gingival border of the gum tissue (Fig. 198). The inflammation spreads through

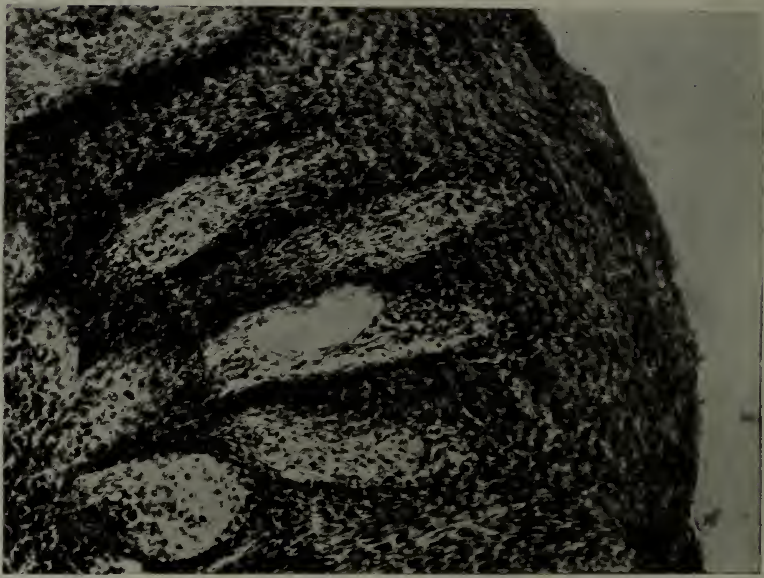


Figure 198
Inflammation of the gum margin (original).

Figure 199
Section deeper at the alveolar border (original). Active inflammation around two arteries which are becoming thickened.

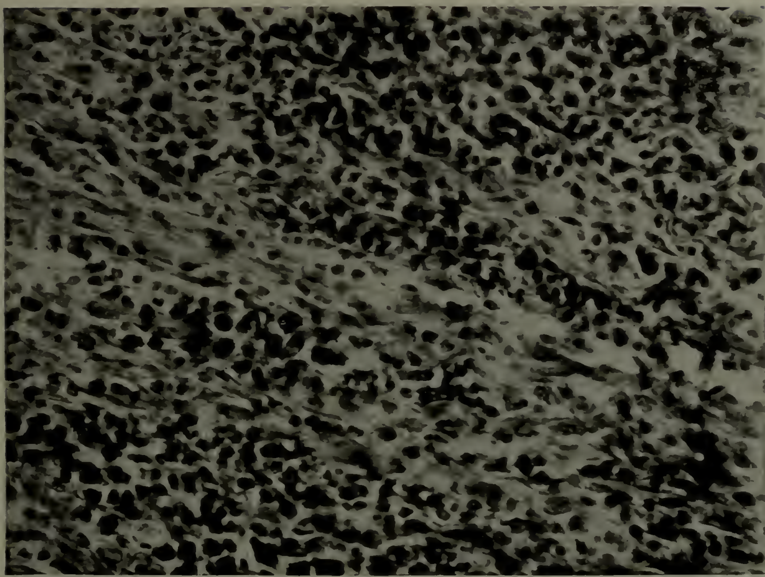


FIGURE 200
Active inflammation in peridental membrane and trabeculae (original).

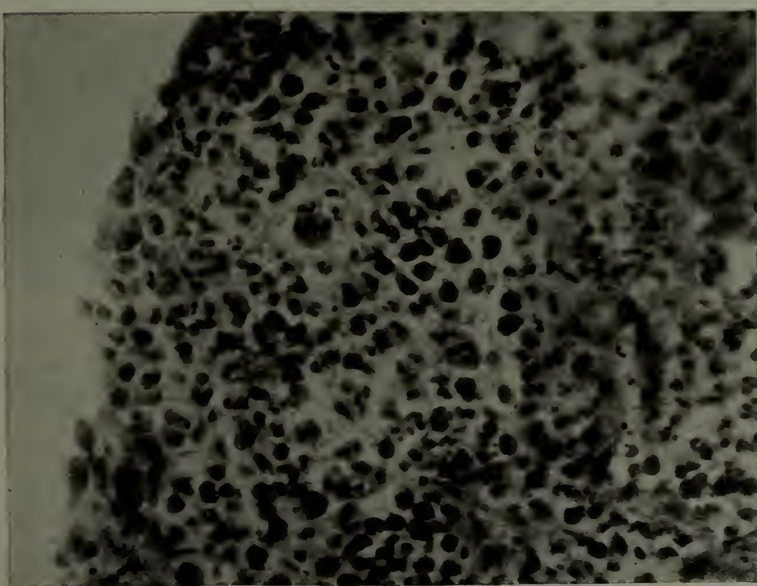


FIGURE 201
Violent inflammation in the peridental membrane and trabeculae (original).

the arteries (Fig. 199) into the deeper tissue of the peridental membrane and alveolar process (Fig. 200). Round cell infiltration rapidly increases, but some of the fibrous tissue may yet be seen. The bone has been destroyed, beginning at the gum margin or in the peridental membrane and extending toward the apical end of the root or outward toward the mucous membrane of the mouth. Nothing remains but the trabeculae or fibrous tissue which originally held the bone cells. The irritation is now so great that the exudate of round cell inflammation rapidly increases, until the tissues are entirely obliterated (Fig. 201). The leucocytes now collect in large numbers within the fibrous tissue. Liquefaction and disintegration of tissue occurs, forming pus pockets (Fig. 202).

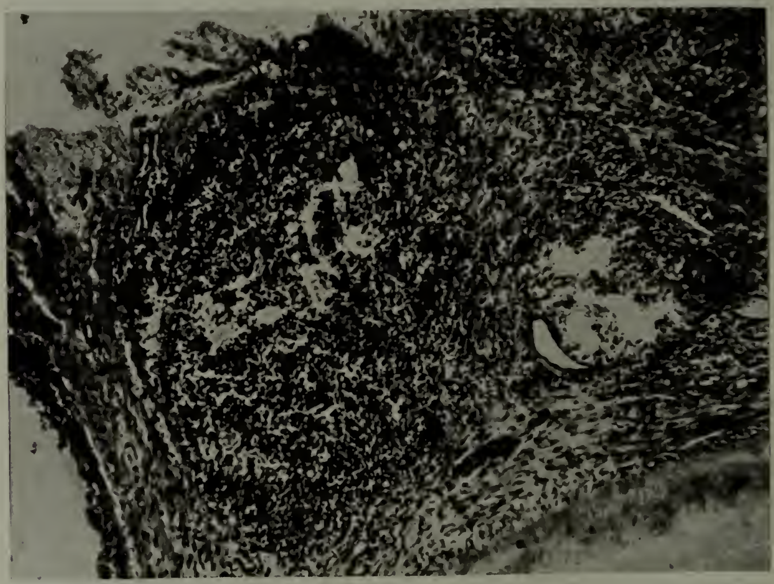


FIGURE 202

Shows the root of the tooth, the peridental membrane, active inflammation in the trabeculae and the formation of two abscesses. Note that both these abscesses are located in what was once the avleolar process. The peridental membrane can be readily observed between the root of the tooth and the nearest abscess (original).

DENTO-ALVEOLAR ABSCESS is a term applied to an accumulation of pus at the apical end of the root of a tooth due to death of the dental pulp and other irritations. When death of the pulp occurs, decomposition takes place and gases form in the pulp chamber. The gases expand and an outlet is acquired through the end of the root of the tooth. These gases and other irritations set up inflammation in the peridental membrane.

The other irritations may be foreign substances forced through the end of the root or poisons in the organism passing through the blood stream. These irritants set up interstitial gingivitis in the arteries running through the peridental membrane and also into the alveolar process and maxillary bone. Interstitial gingivitis becomes quite diffused. Bone absorption (halisteresis and Volkmann's canal absorption) immediately takes place and a considerable area of bone about the end of the root is destroyed,

FIGURE 203
Thickening of the peridental membrane and trabeculae (original).

FIGURE 204
Shows the removal of the outer plate of bone and exposing the root of the tooth and the alveolar abscess (original).

leaving the fibrous tissue (formerly the trabeculae of the bone) in a thickened condition tightly attached to the end of the root (Fig. 203).

As absorption proceeds, the lime salts in the inflamed area are thus destroyed and the fibrous tissue or trabeculae become organized (Fig. 204). If the tooth is extracted before liquefaction occurs, the fibrous mass may be removed insitu (Fig. 205). A low microscopic section of this

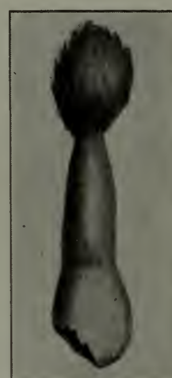


FIGURE 205
Tooth with abscess attached removed from the bone (original).

FIGURE 206
Microscopic illustration of the end of the root of the tooth, (*A*) dentine; (*B*) cementum; (*C*) thickening of peridental membrane and abscess; at (*D*) are two points of liquefaction (original).

picture shows the end of the root with fibrous mass attached and degeneration and liquefaction of tissue just commencing at two points near the center of the mass (Fig. 206 d). A higher magnification showing round-cell infiltration and breaking down of tissue, liquefying into pus is seen in Fig. 207. The pyogenic membrane forming the abscess walls is well shown.

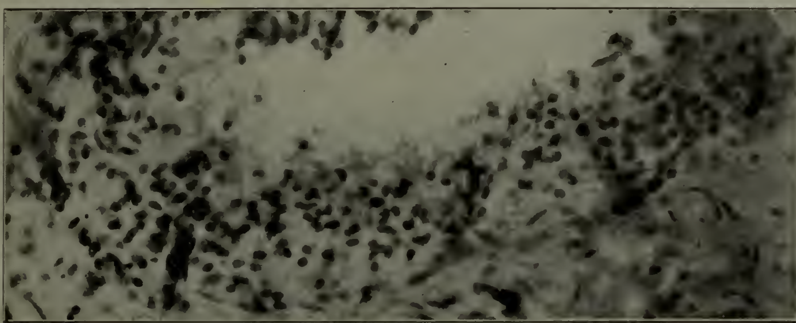


FIGURE 207
Microscopic alveolar abscess sac (original).

The cause of the irritation producing interstitial gingivitis may be so severe and active that not only is there destruction of bone but also of the trabeculae. Under such conditions the root of the tooth is seen denuded of surrounding tissue (Fig. 208).

FIGURE 208
Tooth showing formation and destruction of abscess with carious cavity (original). The irritation which caused the inflammation and formed the abscess was so great as to cause destruction of the sac.

Caries or Necrosis is liable to occur under such violent conditions. When caries results, what is generally understood as a cold or blind abscess occurs.

Peridental Abscesses were first described by Dr. Edwin T. Darby, of Philadelphia, in 1880. These abscesses are always located in the alveolar process between the gingival border and the apical end of the root of the tooth. Abscesses in this locality are always the result of irritants of a toxic nature in the blood stream. Irritants and toxins may be drug or metal poisons or autointoxication due to intestinal putrefaction and to faulty metabolism. These poisons, circulating in the blood, collect in the arteries and capillaries in the alveolar process and frequently produce different colors in the mucous membrane; thus, the blue line of lead, the red of mercury, the green of brass. Not infrequently blue spots, sometimes round and sometimes long, are seen at different localities under the mucous membrane over the alveolar process. They appear to be an accumulation of indican in the tissue under the mucous membrane. Those persons who are seriously affected by intestinal fermentation and putrefactive changes due to meat-eating have an accumulation of indican in the blood vessels for weeks and months before serious results occur in the alveolar process or other parts of the body. Again, a very small amount of indican or other poisons, accumulations of only a few weeks, will cause considerable disturbance in the alveolar process as well as in other body organs.

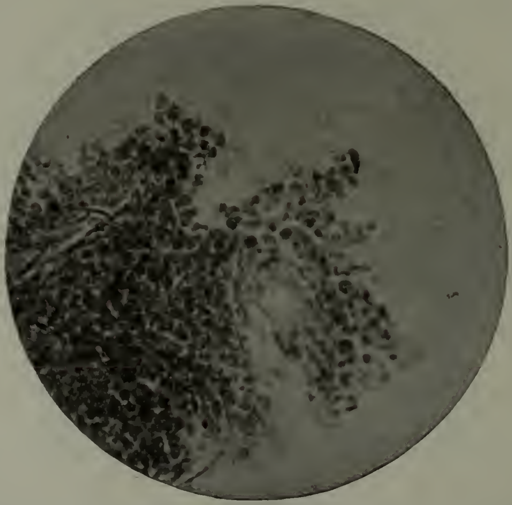


Figure 209
Active inflammation of peridental membrane due to mercurial poisoning (original).

The history of the formation of a peridental abscess is like that already described in relation to the dento-alveolar abscess due to gases. The nerves and arteries enter the alveolar process and pass through as far as the root of the tooth. The poisons set up irritation in the arteries and vessels of Von Ebner and halisteresis and Volkmann's canal absorption results. Abscesses form in the area of the trabeculae and discharge their contents upon the surface of the alveolar process.

Cases in Point. A few illustrations of peridental abscess will not be out of place. Fig. 209 illustrates active inflammation of the peridental

Figure 210
Breaking down of tissue and the formation of abscesses due to mercurial poisoning (original).

membrane in a dyspeptic, debilitated, asthmatic forty-eight-year-old merchant, who had been under calomel and tonic treatment for less than two weeks. When he came under observation, the mucous membrane and gums were much inflamed, marked sialorrhea, teeth loose, the gums swollen, with pus oozing from them and the breath had a decided metallic odor. At my suggestion his physician stopped the calomel. In a few days, the soreness and swelling were so reduced the deposits could be removed. When the patient was discharged cured, the entire buccal

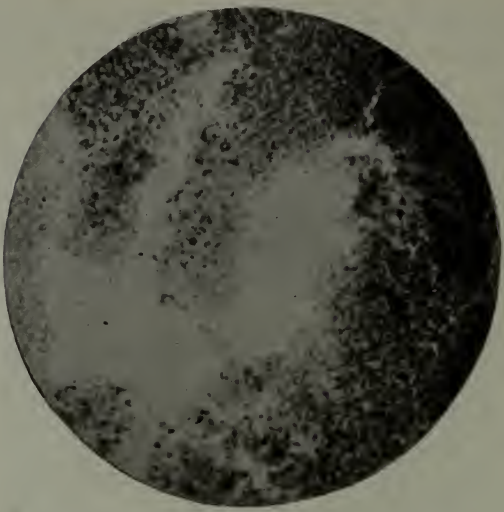


Figure 211
Active inflammation of peridental membrane and trabeculae due to lead poisoning (original).

Figure 212
Four abscesses due to lead poisoning (original). The root of the tooth may be seen in the right hand corner, a little higher up an abscess is forming in the peridental membrane. Three abscesses are forming in the trabeculae which was originally alveolar process.

cavity was in a healthy condition, other than the right inferior second molar, which required removal. This tooth was placed immediately in fifty per cent alcohol for twenty-four hours, then absolute alcohol for twenty-four hours more. The membranes had receded about two-thirds the length of the root. Sections for microscopic purposes were made from the lower third of the root. Of these sections a small fragment of inflamed peridental membrane and trabeculae is observed. Fig. 210 exhibits violent round cell inflammations, degeneration and liquefaction of tissue or abscesses.

A thirty-five-year-old diabetic painter came under observation for lead poisoning. His gums were swollen, there was decided sialorrhea, the teeth were loose, and pus flowed from the gums. Three loose teeth were removed and placed in alcohol. Sections from the upper third of the left superior second bicuspid, on microscopic examination, gave results similar to those already described in mercurial poisoning. Fig. 211 shows round cells of inflammation. Fig. 212 illustrates very marked degeneration of

FIGURE 213
Four abscesses in the peridental membrane and trabeculae in a diabetic man (original).

the peridental membrane and trabeculae. In the right hand corner are seen the root of the tooth dentin and cementum. The whole surface of the membrane is in an advanced stage of inflammation. Just at the

border of the root is evident an area of membrane softening. Just beyond, but joining, is noticeable breaking down of tissue. In the center are seen two areas of softened tissue more advanced in degeneration.

Two cases from my collection of slides excellently show peridental abscess. These illustrate the wide range of diseases in which it may occur. Fig. 213 illustrates the four stages of abscess in the peridental membrane and trabeculae of a sixty-eight-year-old man, a contractor. He was a diabetic, and a neurasthenic with autointoxication, which finally culminated in kidney lesions. The illustration shows active inflammation at different points, the two lower areas breaking down and liquefaction of tissue. The upper space shows an abscess with bacteria within, while without is seen round-cell inflammation.

The following scorbutic case was referred to me by Dr. George W. Johnson of Chicago: A twenty-five-year-old American was admitted to Cook County Hospital for the Insane, December 2, 1892, suffering with melancholia, attended by delusions of persecution, and suicidal tendencies marked by refusal of food. Through the kindness of Dr. Johnson, I was allowed to see this patient. I found none of the teeth very loose, showing

FIGURE 214
Active inflammation in the trabeculae of a scurvy patient (original).

the disease was superficial. I removed two teeth that were decayed and the most loose. These were prepared for the microscope in the usual way. Fig. 214 shows the gums and peridental membrane and trabeculae in an active state of inflammation. Small blood vessels are observed in different localities, with round-cell infiltration extending into the tissue. Fig. 215,

FIGURE 215
Active inflammation around an artery with liquefaction and formation of an abscess in same patient (original).

the root of the right superior second bicuspid with peridental membrane and trabeculae attached, shows active inflammation about an artery which has thickened, and an area of tissue degeneration forming an abscess.

Summary

When, in the course of interstitial gingivitis, the exudates consist of leucocytes, round-cell infiltration takes place, producing pus, leading to ulceration and abscess.

These conditions take the form of pyorrhoea alveolaris, dento-alveolar abscess, or peridental abscess.

Pyorrhoea alveolaris results from local irritation at the gingival border of the gum tissue, spreading through the arteries into the alveolar processes, absorbing the latter and exudating leucocytes.

Dento-alveolar abscess is essentially a similar process at the apical root of the tooth, due to irritation set up by the gases and poisons of a dead pulp. When caries ensues, a cold or blind abscess results.

Peridental abscesses are located between the gingival border of the gum and the apical root, and are always due to toxins in the blood, often to autotoxemia. The poisons frequently collect in the vessels of the alveolar process, showing as colors in the mucosa, e. g. the blue line of lead, red line of mercury, green of brass, and blue spots of indican. The pathology is essentially the same as the two former conditions.

Chapter XXIII

THE VAULT

AFTER considering the jaws, their alveolar processes and the dental arches, it is now the intention to study the vault. The shape and position of the vault depends upon the shape and position of these structures.

Three normal types of vault are recognized, the large, round, low vault, with a normal dental arch of the brachycephalic and the large, long, higher vault, with normal dental arches of the dolichocephalic. These two extremes blend and the mesaticephalic vault results, which may be normal or abnormal in outline, according to the size of the jaw in its relation to the number of the teeth.

The shape of the vault takes the general contour of the three types of head. Where measurements are taken, there is the greatest variance in all directions, showing that no two are alike in nationality or class.

Measurements were made of vaults among Caucasians and negroes who possessed large, well developed, normal jaws, dental arches and vaults. There were twelve brachycephalic, twelve mesaticephalic, six dolichocephalic, Caucasian; there were six each brachycephalic, mesaticephalic and dolichocephalic, negroes. While a larger number would perhaps give better results, yet there are a sufficient number to show the variability of the class.

The height of the vault was obtained by a specially made instrument called a palatometer. The extreme points of the instrument (Fig. 216) rest on the superior alveolar process between the second bicuspid and the first permanent molars. With the left hand, the shaft at the handle is turned, carrying the perpendicular shaft, upon which the scale is engraved, up to the center of the vault. When the instrument is removed, the height of the vault is readily noted upon the scale.

Upon examination of the figures of the brachycephalic, white, the first six lateral cephalic indexes are 84. Taking the width of the dental arch we find that it varies from 2.12 to 2.62; outside second bicuspids, from 1.75 to 2.37; width of vault between second bicuspids, from 1 to 1.37; antero-posterior, from 1.87 to 2.37, while the height of the vault varies from .44 to .62. In the mesocephalic, white, the range varies from 2 to 2.50 in width of dental arch; width outside of second bicuspids, from 1.62 to 2.25; width inside second bicuspids, from 1 to 1.86; antero-posterior, from 2 to 2.37, and height of vault, from .31 to .68. Dolichocephalic: The range width of dental arch is from 2 to 2.37; width outside second

FIGURE 216

Palatometer (original). This instrument is for the purpose of measuring the height of the vault. The instrument held in the right hand is placed upon the gum margin between the second bicuspids and first permanent molars. The box on the end of the central arm is on a level with the points of the instrument. With the left hand, the shaft is turned which carries the measure arm to the vault of the mouth. The instrument is then removed and the height of the vault is registered upon the instrument.

BRACHYCEPHALIC—WHITE

NO.	INDEX.	WIDTH OUTSIDE 1ST MOLAR.		WIDTH OUTSIDE 2ND BICUSPIDS.		WIDTH BETWEEN 2ND BICUSPIDS.		ANTERO-POSTERIOR.		HEIGHT OF VAULT.		TEMPERAMENT.
		In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	
1	84	2.37	60.19	2.12	53.84	1.25	31.75	1.87	47.49	0.44	11.17	Nervo-sanguine
2	84	2.12	53.84	1.87	47.49	1.25	31.75	2.12	53.84	0.50	12.70	Nervo-sanguine
3	84	2.62	66.53	2.37	60.19	1.37	34.77	2.37	60.19	0.50	12.70	Nervo-sanguine
4	84	2.12	53.84	1.87	47.49	1.25	31.75	....	.....	0.56	14.22	Nervo-bilious
5	84	2.37	60.19	1.87	47.49	1.25	31.75	2.12	53.84	0.62	15.74	Lympho-sanguine
6	84	2.12	53.84	1.75	44.45	1.00	25.40	2.25	57.15	0.62	15.74	Sanguino-bilious
7	81	2.37	60.19	2.12	53.84	1.37	34.77	2.18	55.37	0.50	12.70	Nervo-sanguine
8	81	2.00	50.80	1.87	47.49	1.31	33.27	1.87	47.46	0.56	14.22	Nervo-bilious
9	81	2.12	53.84	1.87	47.49	1.06	26.92	....	.....	0.37	9.39	Nervous
10	82	2.00	50.80	1.75	44.45	1.00	25.40	2.50	63.50	0.56	14.22	Nervous
11	82	2.00	50.80	1.87	47.49	1.06	26.92	2.25	57.15	0.62	15.74	Sanguine
12	82	2.25	57.15	2.00	50.80	1.12	28.70	2.12	53.84	0.68	17.27	Sanguine

MESOCEPHALIC—WHITE

No.	Index.	Width outside 1st molar.		Width outside 2nd bicuspids.		Width between 2nd bicuspids.		Antero-posterior.		Height of vault.		Temperament.
		In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	
1	79	2.25	57.15	2.00	50.80	1.18	29.97	2.00	50.80	0.56	14.22	Sanguine
2	79	2.25	57.15	2.00	50.80	1.25	31.75	....	.....	0.56	14.22	Nervo-bilious
3	79	2.00	50.80	1.62	41.15	1.00	25.40	....	.....	0.56	14.22	Sanguine
4	79	2.50	63.50	2.25	57.15	1.37	34.79	2.25	57.15	0.50	12.70	Sanguine
5	78	2.12	53.84	1.75	44.45	1.86	26.92	....	.....	0.68	17.27	Nervous
6	78	2.37	60.20	2.12	53.84	1.37	34.79	2.25	57.15	0.56	14.22	Nervo-sanguine
7	77	2.25	57.15	2.00	50.80	1.18	29.97	....	.....	0.56	14.22	Nervo-bilious
8	77	2.25	57.15	2.00	50.80	1.00	25.40	2.25	57.15	0.44	11.17	Nervous
9	76	2.06	52.32	1.75	44.45	1.00	25.40	....	.....	0.44	11.17	Lymphatic
10	76	2.37	60.20	2.12	53.84	1.25	31.75	2.37	60.20	0.56	14.22	Nervo-bilious
11	75	2.00	50.80	1.75	44.45	1.00	25.40	2.00	50.80	0.31	7.87	Neurotic
12	75	2.18	55.37	2.00	50.80	1.25	31.75	....	.....	0.50	12.70	Neurotic

DOLICHOCEPHALIC—WHITE

NO.	INDEX.	WIDTH OUTSIDE 1ST MOLAR.		WIDTH OUTSIDE 2ND BICUSPIDS.		WIDTH BETWEEN 2ND BICUSPIDS.		ANTERO-POSTERIOR.		HEIGHT OF VAULT.		TEMPERAMENT.
		In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	
1	72	2.25	57.15	2.12	53.84	1.50	38.10	2.12	53.84	0.75	19.05	Nervo-bilious
2	72	2.25	57.15	2.00	50.80	1.25	31.75	2.12	53.84	0.62	15.74	Bilious
3	72	2.00	50.80	1.87	47.49	1.25	31.75	2.18	55.37	0.75	19.05	Nervo-lymphatic
4	72	2.37	60.19	2.00	50.80	1.44	36.54	2.31	58.67	0.75	19.05	Sanguine
5	71	2.06	52.32	1.87	47.49	1.25	31.75	....	.....	0.81	20.75	Sanguine
6	66	2.25	57.15	2.00	50.80	1.31	33.27	....	.....	0.75	19.05	Nervo-bilious

BRACHYCEPHALIC—COLORED

No.	Index.	Width outside 1st molar.		Width outside 2nd bicuspids.		Width between 2nd bicuspids.		Antero-posterior.		Height of vault.	
		In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.
1	87	2.87	72.90	2.00	50.80	1.31	33.27	2.18	55.37	0.56	14.22
2	87	2.50	63.50	2.25	57.15	1.62	41.15	2.12	53.84	0.50	12.70
3	85	2.37	60.20	2.00	50.80	1.37	34.77			0.62	15.74
4	84	2.25	57.15	2.00	50.80	1.31	33.27	2.00	50.80	0.75	19.05
5	84	2.50	63.50	2.12	53.84	2.50	63.50	2.25	57.15	0.50	12.70
6	81	2.50	63.50	2.00	50.80	1.37	34.79	2.25	57.15	0.75	19.05

MESOCEPHALIC—COLORED

No.	Index.	Width outside 1st molar.		Width outside 2nd bicuspids.		Width between 2nd bicuspids.		Antero-posterior.		Height of vault.	
		In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.
1	80	2.50	63.50	2.25	57.15	1.62	41.15	2.31	58.67	0.62	15.74
2	79	2.81	71.37	2.50	63.50	1.62	41.15	2.25	57.15	0.62	15.74
3	79	2.25	57.15	2.00	50.80	1.50	38.10	2.00	50.80	0.62	15.74
4	78	2.50	63.50	2.50	63.50	1.50	38.10	2.37	60.20	0.62	15.74
5	78	2.12	53.84	1.50	38.10	1.31	33.27	2.12	53.84	0.62	15.74
6	75	2.37	60.20	2.00	50.80	1.37	34.79			0.50	12.70

DOLICHOCEPHALIC—COLORED

No.	Index.	Width outside 1st molars.		Width outside 2nd bicuspids.		Width between 2nd bicuspids.		Antero-posterior.		Height of vault.	
		In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.
1	70	2.12	53.84	1.87	47.49	1.18	29.97	2.18	55.37	0.56	14.22
2	69	2.50	63.50	2.12	53.84	1.50	38.10	2.25	57.15	0.62	15.74
3	67	2.50	63.50	2.18	55.37	1.50	38.10	2.25	57.15	0.62	15.74
4	67	2.25	57.15	2.00	50.80	1.18	29.97	2.25	57.15	0.62	15.74
5	63	2.25	57.15	2.12	53.84	1.50	38.10	2.25	57.15	0.62	15.74
[illegible]	60	2.50	63.50	2.25	57.15	1.75	44.45	2.37	60.20	0.68	17.27

BRACHYCEPHALIC, AVERAGE—WHITE AND COLORED

RACE.	WIDTH OUTSIDE 1ST MOLAR.		WIDTH OUTSIDE 2ND BICUSPIDS.		WIDTH INSIDE 2ND BICUSPIDS.		ANTERO-POSTERIOR.		HEIGHT OF VAULT.	
	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.
White....	2.22	56.38	1.98	50.29	1.19	30.22	2.16	54.86	0.54	13.71
Colored....	2.33	59.18	2.06	52.32	1.53	38.86	2.16	54.86	0.61	15.49

MESOCEPHALIC, AVERAGE—WHITE AND COLORED

RACE.	WIDTH OUTSIDE 1ST MOLAR.		WIDTH OUTSIDE 2ND BICUSPIDS.		WIDTH INSIDE 2ND BICUSPIDS.		ANTERO-POSTERIOR.		HEIGHT OF VAULT.	
	In.	Mm.	In.	Im.	In.	Mm.	In.	Mm.	In.	Mm.
White....	2.21	56.13	1.95	48.53	1.16	29.47	2.18	55.37	0.52	13.20
Colored....	2.42	61.36	2.12	53.84	1.49	37.55	2.16	54.86	0.60	15.24

DOLICHOCEPHALIC, AVERAGE—WHITE AND COLORED

RACE.	WIDTH OUTSIDE 1ST MOLAR.		WIDTH OUTSIDE 2ND BICUSPIDS.		WIDTH INSIDE 2ND BICUSPIDS.		ANTERO-POSTERIOR.		HEIGHT OF VAULT.	
	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.	In.	Mm.
White...	2.19	55.62	1.97	50.03	1.50	38.10	2.18	55.37	0.74	18.79
Colored...	2.35	59.69	2.09	53.08	1.42	36.06	2.26	57.40	0.62	15.74

bicuspids, 1.87 to 2.12; width between second bicuspids, from 1.25 to 1.50; antero-posterior, from 2.12 to 2.31; height of vault, from .62 to .81.

The range of figures in each group is so great, and differs so much from each other, that it will be impossible to say that any two possess the slightest resemblance to each other. By comparing one group with another, it will be seen that there is very little difference as regards width and length of dental arch, and width of vault. There is, however, quite a difference in height of vault.

By comparing the figures in the table of the lateral index, we do not observe the slightest resemblance in width, height or temperament, nor

can we observe the slightest resemblance in the contour of the vault and head. It has been claimed that the shape of the vault is influenced by the intellect of the individual; that is, the most intellectual people possess the highest vaults. With a view of ascertaining the correctness of this theory, I measured the heads of six brachycephalic (Plates 29 and 30),* six mesocephalic (Plates 31 and 32), and six dolichicephalic (Plates 33 and 34), colored people—waiters in hotels and restaurants. The white people examined consisted of bankers, editors, medical men, students, architects, bookkeepers—in fact, the most intelligent men that I could find.

By comparing the brachycephalic heads we notice that the highest lateral index in the white individuals is 84, in colored 87. The highest width, outside of first permanent molar, is white 2.62, colored 2.87. This seemed to me quite remarkable. The lowest white 2, colored 2.25. In width of vault, between second bicuspids, highest, white 1.37, colored 1.62; lowest, white 1, colored 1.31. Antero-posterior, greatest length, white 2.50, colored 2.25. Height of vault, highest white 68, lowest 37, with an average of 54; colored highest 75, lowest 50, with an average of 61.

Mesocephalic—Highest lateral index, white 79, colored 80. Highest width outside first permanent molar, white 2.50, colored 2.81; lowest, white 2, colored 2.12. Width of vault between second bicuspids, highest, white 1.86, colored 1.62; lowest, white 1, colored 1.31. Antero-posterior, highest, white 2.37, colored 2.37; lowest, white 2, colored 2. Height of vault, highest, white .68, colored .62; lowest, white .31, colored .50; average, white .52, colored .60.

Dolichocephalic—Highest lateral index, white 72, colored 70. Greatest width outside first molar, white 2.37, colored 2.50; lowest, white 2, colored 2.12. Width of vault between second bicuspids, highest, white 1.50, colored 1.75; lowest, white 1.25, colored 1.18.

Antero-posterior—Greatest length, white 2.31, colored 2.37; smallest white 2.12, colored 2.18. Height of vault, highest, white .81, colored .68; lowest, white .62, colored .56; average, white .74, colored .62.

In reviewing the figures we notice that the colored people possess the roundest heads, while the width of jaw is larger in white, but in the other divisions the jaws are more uniform in width.

A point which must not be lost sight of, and one that I have frequently noticed in ancient skulls, is that in the colored race the jaw does not diminish in width anterior to the first permanent molar as it does in the white race. The height of vault seems to be much greater in the colored race than in the white, with the exception of the dolichocephalic heads, where it is higher in the white race. The height of vault, like other measurements, is more uniform in the white race. Comparing the figures of the colored

* See "Osseous Deformities of the Head, Face and Teeth."

with white people it will be seen, in the average, that the width and antero-posterior measurements of the colored people are the largest.

Since the highest vaults in the brachycephalic and mesocephalic heads are found among colored people, and in the dolichocephalic among the white, we must conclude that intelligence has nothing whatever to do with the contour of the vault, and that there is no more comparison between the vault and the contour of the heads of colored people than there is in white individuals.

The most striking point, in a general way, is the fact that the jaws of the negroes are the largest and their vaults are the highest. This is to be expected, since in phylogeny, the negro is the highest in normal physical development. Changes in size and shape of the vault take place rapidly in evolution and degeneration of the Caucasic races from the highest physical type.

Deformed Vaults are due (1) to an irregularity in the arrangement of the dental arch, (2) to an abnormal development of the median suture and (3) to the hypertrophy of the alveolar process and maxillary bones. Irregularities in arrangement of the dental arch are the result of two causes: (1) neuroses of development, producing arrest of development of the maxillary bone; (2) local causes, or accident. Those produced by an arrest of development take typical forms, which I have classified and described in another chapter by taking 3,000 models of irregularities of the teeth and grouping them under the heads of V, partial V, semi V, saddle, partial saddle, and semi-saddle. The irregularities of the teeth produced by local causes do not take typical forms but are as numerous as the cases.

The different forms of dental arches due to neuroses of development are discussed and illustrated in Chapter XVIII, "The Dental Arches."

The following tables will exhibit the differences in the heights of vaults, both in normal and defective jaws. The height is taken centrally and vertically from the gingival plane on a transverse line intersecting the gingival crests between the second bicuspids and first molars.

NORMAL JAW

Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.
.21	1	.40	159	.56	936	.71	149
.25	2	.43	182	.59	218	.75	427
.28	70	.46	69	.62	514	.78	69
.31	171	.50	199	.65	150	.81	75
.34	169	.53	429	.68	568	.84	12
.37	146	...	...	...	...	...	...

Total number of cases, 4,614. Average height of vault, .58 of an inch.

SADDLE-SHAPED ARCH

Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.
.21	..	.40	..	.56	6	.71	5
.25	..	.43	..	.59	5	.75	5
.28	..	.46	3	.62	4	.78	1
.31	..	.50	5	.65	..	.81	1
.34	..	.53	5	.68	3	.84	..
.37	1	...	..	...	..	..	..

Total number of cases, 44. Average height of vault, .60 of an inch.

V-SHAPED ARCH

Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.
.21	..	.40	1	.56	15	.71	1
.25	..	.43	..	.59	4	.75	2
.28	..	.46	3	.62	9	.78	..
.31	2	.50	8	.65	..	.81	1
.34	..	.53	3	.68	5	.84	..
.37	4	...	..	...	..	...	..

Total number of cases, 58. Average height of vault .55 of an inch.

SEMI-V AND SEMI-SADDLE-SHAPED ARCH

Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.	Height of Vault.	No. of Cases.
.21	..	.40	..	.59	1	.75	..
.25	1	.43	1	.62	4	.78	1
.28	..	.46	..	.65	2	.81	..
.31	..	.50	3	.68	..	.84	..
.34	..	.53	3	.71	2	...	..
.37	1	.56	5	...	..	...	.

Total number of cases, 24. Average height of vault, .56 of an inch.

By comparing the measurements of normal with deformed vaults, it will be seen that there is as wide a range in height among normal vaults as in the deformed. In the normal vaults. the greater number is found at .71 of an inch in height, while in the deformed vaults the greater range is

FIGURE 217
Casts of jaws of children from two to six years of age (original). The vaults are low, almost flat, and ossification of the suture has occurred.

from .71 to .78 of an inch. The average height of deformed vaults is practically the same as that of healthy normal vaults. The difference is due to the narrow contracted dental arch and is apparent and not real.

There is quite a range in height in normal as well as in deformed vaults. The range, however, varies but little in each class. Since, therefore, there are high vaults as well as low in normal dental arches, the theory that the vault is carried upwards, by lateral pressure from without, is not tenable. There are many other reasons to show why this theory is fallacious. These are discussed elsewhere. The one already noted above, according to my researches, is sufficient for our purpose in this work.

What argument can be used to account for high vaults in both normal and deformed? A study of Fig. 217 will throw some light upon this question. These illustrations are those of children ranging from two to six years of age. All have their temporary teeth. No. 6 has the first permanent molars coming into place. There is very little difference in the height of these vaults. It is after the sixth year that the great change in the vault takes place. There is a slight difference in the height of vaults in the six illustrations of jaws with deciduous teeth and this difference must be accounted for, as well as the greater changes which come later.

These changes are due to difference in development of the rami in which the ontogeny recapitulates the phylogeny consequent upon an unstable nervous system. The line of least resistance in rami development is not unlike that of jaw development in which the growth takes the line of least resistance.

The line of least resistance is toward the larger rami of the negro as well as toward a smaller jaw of evolution. In the person with an unstable nervous system, the rami is as liable to develop long as short.

With this explanation, it will be noted that the rami lengthen out of proportion to the jaw development. In order that the teeth may articulate, the alveolar process, (instead of the teeth) grows upwards and downwards to meet the inharmony of development. A slight difference in height of vault, therefore, is due to a lengthening of the alveolar process downward and not to the vault being carried higher up. The great change takes place between the sixth and twelfth year when the second set of teeth come into place. The gradual lengthening of the vault is beautifully demonstrated.

Any one may verify these statements by taking measurements with the author's palatometer (Fig. 216) once a year in a child from two to twelve years of age.

Abnormal Development of the Median Suture. The effect of an unstable nervous system on development of the median suture is striking. As in all bone development, the cells sometimes develop early and some-

times they develop in a dense form; sometimes in large quantities, causing hypertrophy, and sometimes scantily with little or no union, depending upon the nerve control of the vasomotor system and the amount of nutriment deposited. The median suture, like all other bone structures, may have large deposits and ossify early, or they may be scanty and ossification take place late in life. Complete ossification occurs as early as two years when all the temporary teeth are in position (Fig. 217). In these six illustrations, from two to six years, ossification is complete and hypertrophy of suture is developing. Sometimes ossification is deferred as late as the thirty-sixth year, or even later. An interesting factor in the development of the median suture is that of mastication. Similar influences do not enter into the uniting of any other suture of the body. The child begins to masticate food at about eighteen months, the act of mastication involving a lateral movement of the two halves of the superior maxilla. This movement causes friction, stimulation and irritation. Deposition of bone cells, therefore, is attracted, and as ossification proceeds, large masses of bone or hypertrophy take place along the suture. The amount varies in different localities. The shape also varies.

Fig. 218 shows the different shapes and positions of the hypertrophy; sometimes the hypertrophy is confined entirely to the anterior part of the vault; sometimes entirely to the middle portion; and sometimes to the posterior part. Ossification of the median suture is frequently slow.

The following history is to the point. A lady, thirty-six years of age, who has been under the author's care for the past fifteen years, has a space between the central incisors of .50 of an inch. No space was observed until the age of twenty. The teeth filled the arch and all antagonized. The lower jaw continued to develop and the act of mastication carried the superior maxillary bones laterally, thus widening the suture, the space filling in and producing a ridge. The depth of the ridge depends upon the amount of irritation. The height of the groove on either side depends upon the depth of the ridge. When there are grooves upon either side, the jaw is always contracted, the alveolar process being nearer the center of the vault. This, together with the ridges, produces the groove. Were it not for excessive development of the median suture and a contracted dental arch, the vault would take the shape of the dotted lines and be of normal development.

Fig. 219 represents the jaws and teeth of a fifty-year-old man. He has been a patient for nineteen years. The space between the central incisors has been growing as the lateral expansion of the two halves of the maxillary bone has progressed. The continued development of the inferior maxilla, the irritation of mastication, and the lateral expansion due to lateral pressure of the inferior teeth against the superior, have caused the

widening of the suture, including the jaws and teeth. The osseous formation of the suture causes the frenum of the lip to be elongated.

When the jaws have developed larger than the long diameter of the teeth and there are spaces between the anterior teeth, occasionally local conditions will cause absorption of bone on the one hand and deposition of bone cells on the other, separating the teeth at the median line.

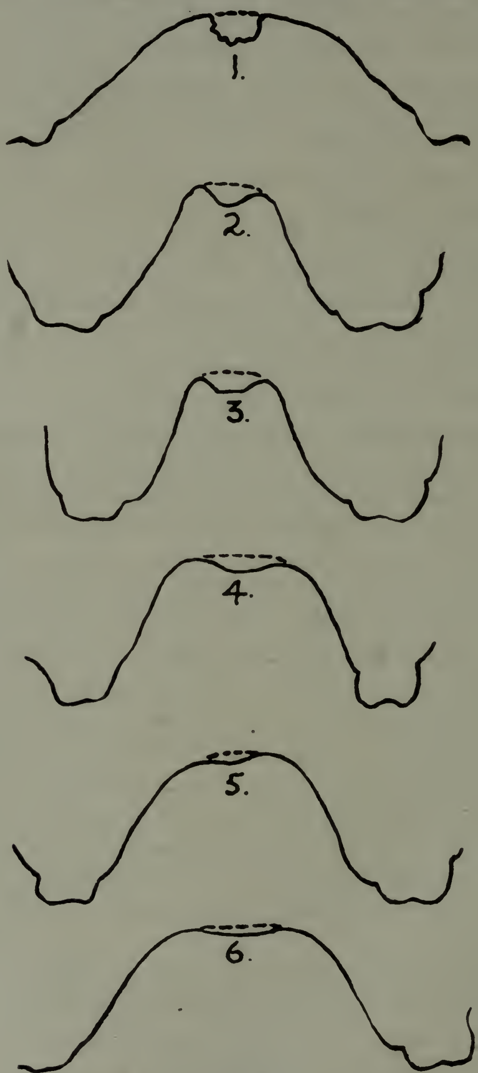


FIGURE 218
Cross section of jaws at the first permanent molar (original). Shows the different shapes of the vault and suture.

Arrests of the bones of the face, nose and superior maxilla in neurotics and degenerates frequently occur. Adenoids, hypertrophy and spurs also assist in preventing nose breathing. In such cases, it is always advisable

FIGURE 219

Cast of jaw and teeth of a fifty-year-old man (original). Shows a lateral growth of the maxillary bone at the median line carrying the teeth laterally. The frenum which has developed excessively extends down between the teeth.

to rapidly separate the superior maxillary bones at the suture by the use of jackscrews. Figs. 220 and 221 show the method of the operation. The younger the child, the quicker and more satisfactory can this be accomplished, since the procedure is a bending of the bones at the lower or middle meatus of the nose. By this method the nasal cavities are enlarged.

FIGURE 220

The application of an appliance for the purpose of opening the suture by spreading the dental arch (George V. I. Brown).

After special treatment by the rhinologist, nose breathing will become established and the child will soon improve in health and mentality. The opening of the suture may be enlarged to any extent necessary to accom-

plish the desired result. The lower dental arch must also be expanded to form a normal articulation.

From 1880 to 1894, I had opened the suture at the median line in fourteen patients, ranging from twelve to sixteen years of age, with most satisfactory results both as to general appearance and to health.

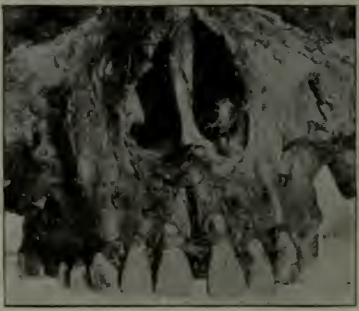


FIGURE 221
Shows the result of spreading the dental arch. The space between the teeth and the opening between the maxillary bones is quite marked (George V. I. Brown).

FIGURE 222
Excessive hypertrophy of the alveolar process producing a deformed vault, natural size (original).

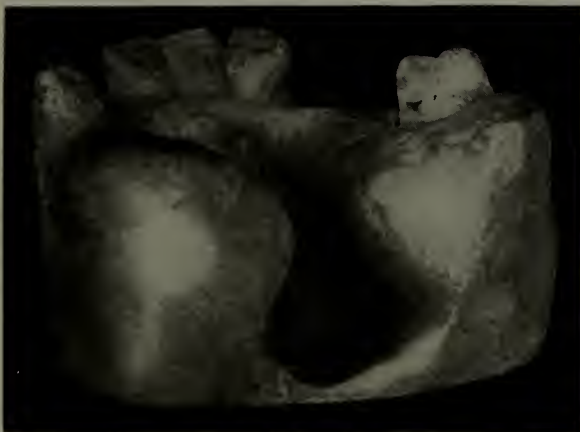


FIGURE 223
Excessive development of the alveolar process, producing a deformity of the vault, natural size (original).

HYPERTROPHY OF THE ALVEOLAR PROCESS AND MAXILLARY BONES producing deformed vaults, was partly considered in Chapter XIX. The milder forms were discussed in relation to the shape of the dental arch and alveolar process. We shall now consider the subject of actual deformity. First, however, it is well to state that what is considered by some specialists a deformed vault, arch or palate, is not the seat of the disease, the seat of the disease being in the alveolar process and not in the vault. The vault is involved only in extreme pathologic conditions, as we shall see later. In all three of the jaws illustrated in Chapter XIX, the alveolar process alone was involved and not the vault. We can easily understand this when we consider that hypertrophy of the alveolar process is rarely, if ever, associated with the first set of teeth. The vaults are usually normal. Hypertrophy of the alveolar process usually begins after the second set of teeth have erupted.

The alveolar process, being a very transitory loose structure, the irritation brought about by the development of teeth and the absorption and depositon of bone in persons with an unstable nervous system, causes the bone to continue development after the teeth are securely held in position, under the law of economy of growth and least resistance.

Development of the alveolar process may continue so as to involve the hard palate and the entire maxillary bone (Fig. 222), carrying the dental

arch laterally to a considerable distance. While in such a state, the vault may be considered deformed, although the cause is in the alveolar process and not in the hard palate.

Fig. 223 is another extreme illustration of the same condition. The anterior alveolar process is only slightly involved while the part connected with the molars is excessively developed. This is also true in the previous illustration and, indeed, in most cases. This point is interesting since an unstable nervous system, previously acquired, may not manifest itself until this very critical time, the fourth period of stress, from fourteen to twenty-one years of age. The child may be strong and well until this period of stress, when an unstable nervous system may develop. Such deformities of the alveolar process are very distressing in many ways.

First, the teeth are carried out of position so that contact in chewing is out of the question.

Second, the gums frequently hypertrophy and develop below the grinding surfaces of the teeth, bleeding easily and thus keeping the mouth in a very unhygienic condition.

Third, the tongue is deprived of free motion to carry the food from one side of the mouth to the other; it cannot assist in speech or song because it cannot be carried into the roof of the mouth. As a rule, however, such a deformity is not externally observable.

Summary

The shape and position of the vault depend upon those of the alveolar process.

Three normal types of vault are recognized; the large, round, low, or brachycephalic; the large, long, high or dolichocephalic; and the blend of these two, or mesocephalic.

There is the greatest variation in vaults within normal limits.

The highest vaults in the brachy and mesocephalic heads are found in the colored race; in the dolichocephalic, among the whites. Hence intelligence has no relation to the contour of the vault.

High vaults being normally compatible with normal arches, the theory that the vault is carried upward by lateral pressure from without is untenable. Observation shows that the high vault is due to a lengthening downward of the alveolar processes to approximate the teeth, in compensation for inharmony in the length of jaws and rami.

Abnormal development of the median suture results from premature or delayed ossification, due to an unstable nervous system. No other suture in the body is subjected to similar conditions of uniting with this one, e. g. the friction, stimulus, and irritation of mastication.

Deformed vaults are caused by (1) irregular dental arches, (2) abnormal development of the median suture, (3) hypertrophy of the alveolar process and the maxillary bone.

The alveolar process, under an unstable nervous system, may continue to develop after the tooth is firmly socketed, and cause hypertrophy, deforming the vault.

Chapter XXIV

CLEFT PALATE AND HARELIP

BEAUTIFUL as the human face is, in its most perfect phase, it is, as Minot has shown from the standpoint of food-getting, an embryonic type.

An Arrest in Phylogeny.—The jaws are needed less and less for purposes of food-getting, chewing, and combat, hence resultant disuse under the law of economy of growth sacrifices them for the benefit of the growing brain and nervous system and to the need the first has of the dermal elements of the skull. Under operation of the law of economy of growth there has occurred the esthetic evolution of the face from the anthropoid to the Apollo Belvedere type, as well as the reverse phase of this, where symmetry of the body as a whole, to preserve brain gains is sacrificed to changes in the nose, jaws, alveolar process, vault and teeth. This struggle for existence strains most developments of points of ossification, and as it is aided by primitive type heredity, spends much of its force on the structures which have gained for race purposes like the jaws and the teeth. The palatal bones are therefore affected.

Cleft palate is divisible into congenital and post-congenital. The post-congenital, while having a predisposing factor of teratologic nature, is often produced by a determining nosologic factor. Congenital cleft palate is divisible into two kinds, complete and partial—complete, when the fissure extends the entire length from the uvula to and including the anterior alveolar process and even the lips; partial, when only a small part of the structure is involved. Thus the cleft may extend through the anterior alveolar process, involving only the incisive bones, which is very rare; when present, single or double harelip almost invariably co-exists. Cases occur where a small portion of the anterior alveolar process and jaw are involved with one or two teeth. The hard palate may be merely involved to the extent of a small fissure, or the whole palate may be wanting. The soft palate may contain the cleft, or the uvula alone may. Cases occur in which the non-development of the intermaxillary bones produces lip fissures.

The problems involved in cleft palate are those of embryogeny as modified by the law of economy of growth by remote atavism, by type heredity, and by the results of characters acquired during the periods of dentition and adolescence and prior to the senile. As soon as the external nares are separated from the mouth in the embryo (Fig. 224) there occurs, as Minot has shown, a partition between the nasal pits and the mouth. This partition in which the intermaxillary bone is differentiated later, is

supplemented by another partition, the true palate, which shuts off the upper part of the oral cavity from the lower, thus adding the upper part to the nasal chamber. The palate is a secondary structure which divides the mouth into an upper respiratory passage and a lower lingual or digestive passage. The palate arises as two shelf-like growths of the inner side of each maxillary process, and is completed by the union of the two shelves in the median line. The shelves so arch as to descend a certain distance into the pharynx, but in the pharynx their growth is arrested, though they may be still recognized in the adult. In the region of the tongue, which

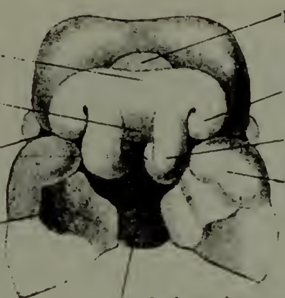


FIGURE 224
Portion of head of about thrity-four days, showing roof of primitive oral cavity (His).

includes more than the primitive of the oral cavity, the palate shelves continue growing. At first they project obliquely downward toward the floor of the mouth, and the tongue rises high between them and appears in sections which pass through the internal nares to be about to join the internasal septum. As the lower jaw grows the floor of the mouth is lowered, and the tongue is thereby brought further away from the internasal septum. At the same time the palate shelves take a more horizontal position and pass toward one another above the tongue and below the nasal septum, and meet in the median line, where they unite. From their original position the shelves necessarily meet in front (toward the lips) first, and unite behind (toward the pharynx) later. In the human embryo, the union begins at eight weeks, and at nine weeks is completed for the region of the future hard palate, and by eleven weeks is usually completed for the soft palate also. The palate shelves extend back across the third and second brachial arches. By migration of the first gill pouch, or in other words of the Eustachian tube, the Eustachian opening comes to lie above the palate (uvula), while the second cleft remains lower down and lies below the palate as the outline of the tonsil.

The uvula appears during the latter half of the third month as a projection of the border of the soft palate. Soon after the two palatal shelves have united, the nasal septum unites with the palate also, and thereby the permanent relations of the cavities are established.

In dealing with the influence of the factors named on embryogeny, the influences of disturbances of balance, at an early period, which would strengthen disappearing structures at the expense of later acquired structures, have to be considered. Such a disturbance would overcome the effects of disuse and create over-growths of primitive structures at the expense of later acquired structures, leading to arrest, atrophy, or even disappearance of these last. The structures of the mouth and nose being exceedingly variable in evolution, and the structures of the jaws and teeth having in man taken an embryonic trend for the benefit of the body as a whole, under the operation of the law of economy of growth, disturbances of balance are peculiarly apt to occur here. Not only is actual growth upset by the operation of this disturbance of balance, but certain potentialities are likewise interfered with. Up to the age of three the central nervous system gains at the expense of the other structures. After this period the other structures gain, but the nervous system while growing, does not maintain its supremacy in growth.

Interferences with lip and palate formation (Figs. 225 and 226) must

FIGURE 225
A woman with double harelip (Carpenter).

begin comparatively early in embryogeny, and hence must imply decided defect on the part of the parents. Any maternal factor, whether arising during a particular pregnancy or inherited, may so check the development of the palate as to produce the various types of deficiency which are observed by surgeons. The influence of heredity requires no special discussion, since it is involved as a rule in serious general defect rather than in localized. Furthermore, maternal environment plays here as elsewhere an enormous part. A defective mother may be so influenced by favorable environment during the first three months of pregnancy, or by removal from bad parental environment during the same period, that the embryo would not only

Figure 226
A woman with cleft palate (Carpenter).

pass through these periods of intra-uterine stress successfully, but would likewise acquire increased potentiality of passing through the later periods successfully. On the other hand, an evil environment or an environment changed for the worse soon after impregnation unfavorably affects embryogeny.

In dealing with the development of the palate, both pre- and post-congenitally, the relations of the hypophysis or pituitary body have to be taken into account, since it has been demonstrated that this body exerts an influence over body growth and the structures thereto related. The hypophysis arises in all vertebrates as an evagination of the ectoderm near the dorsal border of the oral plate, but is separated from the plate by a fold

of the ectoderm. The hypophysis at one stage of its development in mammals is a diverticulum of the oral cavity with one wall attached to the brain and the other formed by a fold dividing the hypophysis from the mouth. The hypophysial diverticulum later elongates and its upper end expands to a considerable vesicle, the lower end remaining narrow as the pedicle. The floor of the brain forms an outgrowth behind the hypophysis which is the representative of the infundibulum. The cementing together of the buccal and cerebral ectoderm over the hypophysial area causes the formation of the two diverticula. The hypophysis then grows rapidly. The pedicle elongates and its lumen is obliterated. The mesenchyma condenses to form the base of the skull (sphenoid). The pedicle entirely aborts, but the position for its passage through the sphenoid, while remaining for some time after birth in about 10 per cent of children dying in hospitals, is ultimately obliterated by growth of the sphenoid cartilage. The infundibulum contributes to the production of the adult hypophysis in mammals, but in lower vertebrates it persists as an integral part of the brain and is differentiated into ganglionic tissue. The pointed end undergoes a knob-like enlargement, which later loses its cavity. Although the differentiation of nervous tissue begins in it, its cells early acquire an indifferent character. It is penetrated by blood-vessels and connective tissue, but the connection with the brain is permanently retained. In the adult the knob, although regarded as the posterior lobe of the hypophysis, is in no sense a part of it. Strain on the development of the hypophysis after birth can not only produce undue growth of bone, but can also check development of it. The influence of the periods of stress during the last months of pregnancy may arrest palatal development through interference with the bone-forming function of the hypophysis, checking the development of bone and cartilage necessary to proper evolution of the palate.

"The antecedent," according to Oakley Coles, "which strikes one *a priori* as being likely to play the most important part in the production of congenital deformities is that of hereditary influence. But though it will be evident that direct influence of heredity in the production of cleft palate is marked and undeniable, no sufficient statistics have as yet been brought forward to show that the actual presence of deformity in the parent has any direct predisposing influence in the child. In other words, though the defective conditions which precede and accompany the phenomenon of cleft palate are almost certain to be referred to parental influence, it is extremely doubtful whether cleft palate is in itself transmissible." Here appears that antiquated view of heredity which takes into account only direct transmission. Heredity involves the complex of type heredity, remote atavism, individual defects or peculiarities of immediate ancestors, maternal environment, and stress period environment. Direct heredity

can occur only when, in embryonic existence, the embryogeny by the law of economy of growth is centered around a given line of least resistance during the struggle for existence between the organs for assimilable nutriment. While a defective ancestor may have defective children, the line of direct expression of the defect is interrupted by the influence of atavism, by the influence of varying environment during embryogeny, and during post-natal periods of evolutionary stress. That cleft palate may be transmissible, Demarquary, Roux, Trelat, Follin, and Duplay have shown, but such transmission is and must be rare, from the factors unfavorable to direct transmission entering into heredity, inclusive of maternal environment during embryogeny.

The deformity rarely occurs, if at all, from maternal impressions. In most of the cases which have come immediately under notice, when one parent had a cleft palate all the children have been born perfectly developed, even though dread of transmitting the deformity was never absent from the mind of the mother. In one case three members of one family have cleft palate—one 17 years, one 30 years, and the third 35. The first and last are women; the other is a married man with family without any trace of the father's deformity. No instance of cleft palate could be found among ancestors or collateral branches of the family. In another family I have obtained the following remarkable history: G. H. C., born 1853, perfect; L. C., born 1855, single harelip and cleft palate; J. F. C., born 1856, perfect; F. W. C., born 1860, double harelip and cleft palate; H. E. C., born 1863, perfect. The paternal grandmother had cleft palate. Five per cent of 1,200 criminals examined by Knecht had cleft palate. In an examination of 495 criminal boys at the Illinois State Reformatory and 1080 at the New York State Reformatory, only one case in each institution was observed. Fourteen per cent of the prostitutes examined by Pauline Tarnowsky had cleft palates. Langdon Down found only a half per cent of cleft palates among congenital idiots. Gresnor found nine cases in 14,466 children, or one in 1607. I examined 1977 feeble-minded children without finding a single case. In 207 blind but one case was observed; in 1935 deafmutes two cases, or about one in 1,000. The percentage among the defective classes is undoubtedly much larger than among normal individuals, but early deaths explain the small percentages. Bland Sutton's experiments with dogs indicate not only the presence of this deformity among animals, but its transmissal. Hereditary defects are evident in the statistics of zoologic gardens. A keeper of the Zoologic Gardens in Philadelphia observed cleft palate in the mouths of lion cubs born in the gardens. Cleft palates were also observed in a number of pups born in Buffalo. Ogle found that 99 per cent of the cubs born in the London Zoologic Gardens had cleft palates. This was ascribed to the artificial

diet of the mother as the result of enforced captivity. Similar results in other gardens in Europe were charged to maternal feeding with meat without bone. Feeding with the whole carcass of small animals greatly diminished these deformities. If cleft palates were sometimes attributable to this cause, other bony structures should likewise be involved. It is hence not astonishing to find many rickety lions born in captivity. Cleft palate has been observed among dogs, sheep, goats, etc. The question whether domesticity does not play in them the alleged parasitic influence of civilization in man can only be solved by knowledge of deformity frequency among wild animals of the same zoologic families.

The difficulties of securing data of the occurence of cleft palate among wild animals are sufficiently shown by the following replies to the question: "Have you ever observed cleft palate among wild animals not in captivity?"

Prof. Osborn is in Europe, but in his absence I have attempted to find an answer to your query in regard to cleft palate. I looked through Windle's 11th to 15th Report on Recent Teratological Literature (Journal of Anatomy and Physiclogy) and also in several encyclopedias and surgical books without success, and I also asked Dr. J. A. Allen, one of the leading mammalogists of the country, if he had ever noted cleft palate in wild animals not in captivity, but have not ever noted a case.

William K. Gregory.

American Museum of Natural History, New York City.

In reply to your query I can say that I have never observed and do not recollect having heard of case of cleft palate in wild animals not in captivity.

J. Symmington.

Queens College, Belfast, Ireland.

I have not seen a case of cleft palate in any wild animal.

Wm. Turner.

Edinburgh.

I have never observed a case of cleft palate among wild animals, nor have I ever heard of one. Several years ago lion whelps were born with cleft palate in the Zoological Gardens of London.

London, England. Bland Sutton.

I have only experience of wild animals bred in captivity. In the Zoological Gardens of Dublin, which I had the supervision of for many years, we have bred lions (between 200 and 300) since 1856. Only very occasionally did cleft palate or other deformity appear amongst the cubs—only once during my time, if I recollect rightly. Of course in my museum work I have had many wild animals pass through my hands which were not bred in captivity, and I never saw a case of cleft palate. At the same time it should be remembered that many collectors would reject a deformed specimen.

In London Zoological Gardens, cleft palate amongst lion cubs used to be very common, I understand.

University of Edinburgh. D. J. Cunningham.

In reply to your letter of the 1st inst., I only know of one case of wild animals being born with cleft palate. The knowledge of this I owe to Mr. R. T. Powch, superintendent of these gardens. He informs me that a litter of tiger cubs born of wild parents were brought up by an English lady in Burmah and found to have cleft palate. As you perhaps know. lion cubs have so constantly a cleft palate that it seems almost if not quite normal for them to be so born in menageries.

Regent's Park, London, England. FRANK E. BEDDARD.

This negative evidence is not equivalent to demonstrating absence of cleft palate among wild animals, for, as I have elsewhere pointed out, animals destroy soon after birth offspring which to them appear peculiar. Cleft palate predisposes to infection by pathogenic bacteria, and hence offspring born in a wild state are not likely to survive. Cleft palate, moreover, is quite frequently associated with deep-seated affections of the nervous system or of the locomotive apparatus.

In the evolution of the palate, ossification is the central point as regards completed development. Arrest of ossification or of its potentiality plays a considerable part in determining the permanency of cleft palate. Reported cases show that the condition is one which sometimes requires merely a temporary stimulus to growth to disappear. The arrest is one of potentiality, not of permanent development. The palate bone develops from a single center at the angle of junction of the two plates of the bone.* The center makes its appearance about the second month. Appearing thus early, it has an impetus which survives the stress of the different periods of intra-uterine development and maternal environment. The influence of type heredity aids rather than arrests ossification of the palate, since tendency to ossify occurs thus early.

The relationship between palatal vault deformities and cleft palate, pointed out by Oakley Coles, is that existing between atrophies, hypertrophies, and arrests of development everywhere. Instability of trophic functions is shown as much in hypertrophies as in atrophies. The instability may affect not only development, but potentialities of development, which it may arrest ere the period when the potentiality is to pass into fulfilment. The same factor which prevents sexual development at the period of puberty may prevent proper development of the vault at the sixth year. The frequency of what may be called palatal hypertrophy as compared with the deficiency shown in cleft palate is an illustration of this impetus. The ease with which the tendency to cleft palatal offsprings is remedied by diet in the menageries shows that the ossification potentialities need but a slight stimulus. Influences interfering with proper development of the hypophysis, which is in such close embryogenetic relations with the palate, interfere with the onset of ossification, or with its proper development.

* Gray's "Anatomy."

From the angle of junction of the two plates the bone ossification spreads inward to the horizontal plate, downward into the tuberosity, and upward into the vertical plate. In the fetus the horizontal plate is much longer than the vertical, and even after it is fully ossified the whole bone is at first remarkable for its shortness. The palate hence requires an additional period to develop after ossification. The complicated relations of the palate to the turbinated and maxillary bones, both under stress from the law of economy of growth as varying structures, place it under varying conditions of nutriment, expressed either in excess or in the deficiency shown in cleft palate. The fact that the palate is permanent compared with the turbinates and the rest of the maxillary bones indicates that, aided by its early ossification tendencies, it tends to survive in the struggle for assimilable nutriment. Heredity of long standing sometimes so affects early development of the palate, however, as to give the other two bones an advantage. This occurs where the preconceptional vitality of the mother is lowered, or where the first two months after conception are periods of extreme strain for the mother. Paternal vitality when lowered affects the early conceptional period. This to some extent involves an influence on maternal vitality, since, as has been repeatedly shown, chiefly after maternal breakdown does paternal defect show itself. In Mongoloid idiocy, as W. A. Hammond has shown, early pregnancies when the mother is healthy are free from such offspring, but later births are of this type.

To such extent is this maternal vitality the case that even syphilis may not arrest development. Thus, as in a case reported by Engel, the husband may be infected during the second month of his wife's pregnancy and immediately infect her. A hearty boy is born with copper-colored eruption about the anus, and later coryza. These symptoms disappear under specific treatment, not to return. The child does not have tertiary lues, but unlike the ordinary cases of congenital syphilis, the secondary stages.

The factors involved in the reproduction of congenital cleft palate are, it is clear from the foregoing facts, partly of an embryogenetic nature, which is connected with ossification evolution, which last in turn is involved in hypophysis development. These factors are not necessarily connected with heredity, albeit the influence of maternal environment cannot be completely excluded. The influences checking palatal development must be present very early in embryogeny, since the palate ossification center is quite early in evidence. The factors affecting this ossification center may entirely arrest ossification, may arrest it irregularly, or may merely arrest its potentiality. In the latter case improved maternal environment has favorable results. In hereditarily defective cases, however, there is an

irregularity of balance giving an undue sway to certain early acquired structures at the expense of others later acquired which leads to increased irregularity, rather than its disappearance. The influence of hypophysis extracts on deficient osseous development is as yet merely suggested. Sufficient is known, however, to indicate that it might be well to use hypophysis extract in cleft palate on the possibility that the arrest was merely an arrest of potentiality, not an arrest of growth.

Summary

The development of face and jaws is influenced, on the one hand, by the sacrifice of these structures to brain gains, and on the other, by atavistic reversions to primitive types.

In this struggle for existence the points of ossification feel the greatest strain, among which are the palatal bones.

Cleft palate is due to congenital and embryonic causes, and is either complete or partial. The complete variety involves the whole structure, from uvula to alveolar process, including even the lip (harelip).

Congenital causes consist in disturbances of nervous poise which strengthen passing structures at the expense of later ones.

Interference with palate formation, necessarily beginning early in embryology, indicates profound parental defects, operating through the pituitary body of the fetus.

While heredity is an important factor, there is no evidence of direct heredity, i. e. of transmission of cleft palate in itself. It rarely, if ever, results from maternal impressions.

Cleft palate is relatively common among the offspring of mentally defective parents. It occurs in animals in captivity but is not observed among wild animals.

Arrest of ossification is the chief determining factor, and as atavism hastens ossification, giving it an impetus to outride periods of stress, it usually aids rather than hinders palate formation.

The relation of vault deformities to cleft palate is that of hypertrophy —which is an expression of trophic instability.

The permanency of the palate as compared with the turbinate and maxillary bones usually causes the palate to survive in struggles for nutriment, but parental low vitality (especially maternal) may so affect the palate as to give the other two bones the advantage.

Considering the part played by the pituitary body, and on the assumption that the defect is only an arrest of potentiality, the administration of pituitary extract in cleft palate might be advisable.

Chapter XXV

THE VERTEBRATE TEETH

Phylogeny and Ontogeny

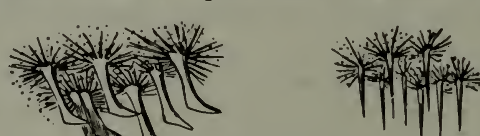
THE teeth, in their phylogeny from the placoid scale through fish, reptile, bird and mammal, exhibit many common characteristics. It is the intention here to simply mention such points as are of interest in the study of dental phylogeny and ontogeny. According to Owen, fish teeth in whatever relation they may be considered, whether in regard to number, form, substance, structure, situation or mode of attachment, undergo more striking modifications than do those of other vertebrates.

Teeth of Fish

Fish teeth are modifications of the placoid scale, namely horny plate, cone, prism or cylinder. Conical teeth are the most numerous and are slender, sharp, blunt or prominent. The great variety of forms renders them useful for many purposes.

The skin of those fish which are covered with spines blends with the mucous membrane at the lips and turns in over the jaws. These spines, or placoid scales (Fig. 227), grow in the dog fish (Fig. 228) and become larger than on the body surface.

The first of the dermal skeletal parts are the scales of fish which differ from the epidermal scales of reptiles and mammals (turtles, alligators,



Dermal papillæ of Monacanthus trossulus.

Dermal papillæ of Monacanthus hippocrepis (magn.)

Figure 227

Spines or placoid scales (Hertwig). These scales or plates may be situated upon the outer surface of the skin or mucous membrane of the mouth. They are modified, however, in shape in different vertebrates.

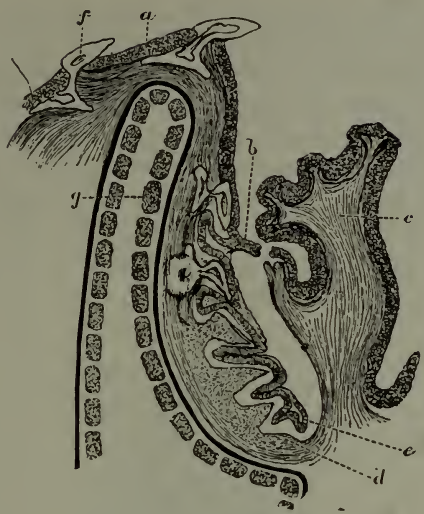


FIGURE 228
Transverse section of lower jaw of dog fish (Tomes). *a*, oral epithelium; *b*, oral epithelium passing on to flap; *c*, protecting flap of mucous membrane (thecal fold): *d*, youngest dentine pulp; *e*, youngest enamel organ; *f*, tooth about to be shed; *g*, calcified crust of jaw.

FIGURE 229
Saggital section of placoid scale (Hofer). *b*, basal plate; *d*, dentine; *p*, pulp cavity; *sch*, enamel. This placoid scale is the genesis of tooth development. Note the broad base and highly developed vascular structure.

armadillos, etc.). They may be traced back to the primitive form, the placoid scales of the Elasmobranchs (sharks, rays, etc.). These rhombic plates, bearing in the middle pointed spines, are called dermal teeth, from their similarity in structure and development to the teeth of the mouth cavity (Fig. 229). They consist of dentine (d) and have a large pulp cavity (p) with numerous blood vessels. Whether the thin layer (sch) covering the tip can be called enamel is a question not yet decided. Der-

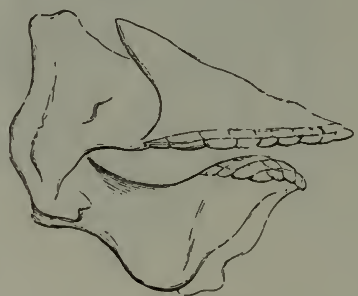


FIGURE 230
Teeth of Port Jackson shark (original). Primitive organs of the skin widely developed over the surface of the jaw.

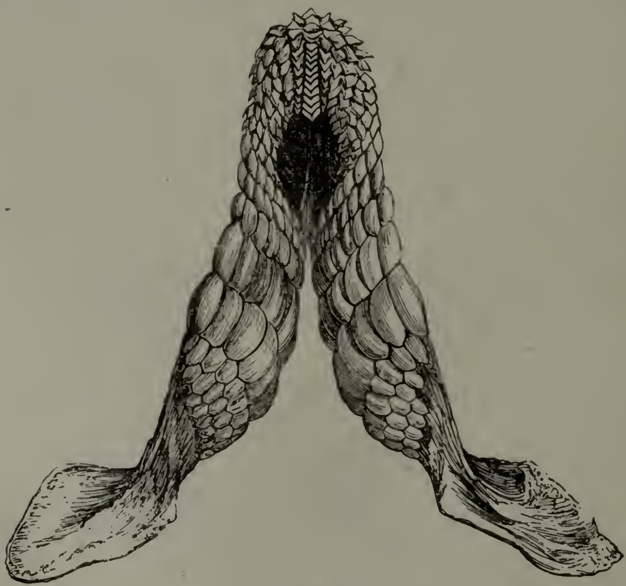


FIGURE 231
Upper jaw of Port Jackson shark (Owen). The teeth in front are pointed; the larger in the middle for grinding purposes. The small teeth at the back part of the jaw are young teeth not yet in use.

mal teeth and true teeth are identical structures, which, because of different position and consequent variation of function, have developed differently.

Shark Teeth (Fig. 230) are nothing more than highly developed spines on the skin, which leads to the belief that teeth, in their phylogenetic development and structure bear similar relation to the primitive structures, namely spines, horny plates and placoid scales (Fig. 231). These spines, horny plates or placoid scales upon the surface are imbedded in tough mucous membrane (Fig. 232) and never acquire a bony connection. The teeth or placoid scales are nourished by nerves and blood vessels spreading

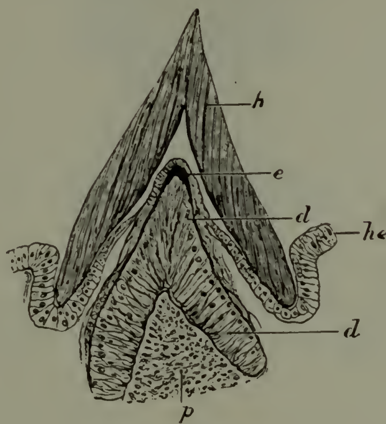


Figure 232
Horny tooth of Bdellostoma (Beard). *D*, calcified dental cap; *e*, enamel; *h*, horny tooth; *he*, epithelial groove in which the base is formed.

out upon the entire under surface. There is, thus, the highest possible source of nourishment in this primitive tooth.

Attachments of fish teeth present a greater diversity in mode, as well as place, than is observed in other vertebrate classes. The most common

Figure 233
The lower jaw of sheep's head, sargus ovis (original). Shows teeth in front and horny plates over surface of jaw.

mode is the cutaneous (Figs. 233 and 234). The teeth of the salarias are simply attached to the gum. Some species have a hollow space, supported upon bony eminences arising from the socket base like feline tribe claws

FIGURE 234
The upper jaw of sheep's head, sargus ovis (original). Shows teeth in front and horny plates over surface of jaw.

(Fig. 235). When they are attached to the fibrous tissue covering the cartilaginous jaw, they are called hinged teeth (Fig. 236). Ossification between the dental pulp and the jaw takes place in some species. The

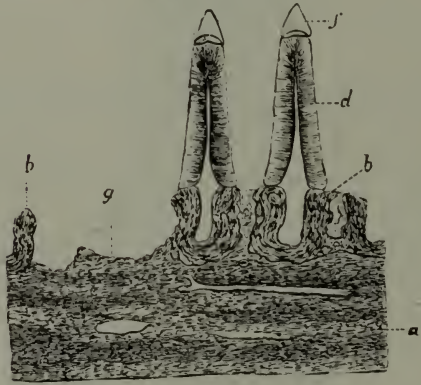


FIGURE 235
Lower jaw of an eel (Tomes). *a*, bone of jaw; *b*, bone of attachment; *d*, dentine; *f*, enamel; *g*, space vacated by shed tooth.

tooth, prior to completion of ankylosis, is connected by ligamentous substances either to plain surfaces, eminences or shallow depressions in the jaw bone (Fig. 237). Sometimes, the side and not the end of the base of the tooth is attached by ankylosis in the alveolar border. In a few

instances, the teeth are implanted in grooves and pockets to which they are attached only by surrounding soft parts, as in the case of the sawfish

FIGURE 236

Hinged tooth of pike (Tomes). *A*, dentine; *b*, elastic rod formed of uncalcified trabeculae which might have become bone; *c*, hinge not itself elastic; *d*, bone of attachment; *e*, bone of the jaw.

rostral teeth (Fig. 238). The incisors of the filefish also afford this curious example of gomphosis. In other fish varieties, where long, powerful, piercing, lancinating teeth are necessary for strength, the broad base of the tooth is divided into a number of long, slender, cylindrical processes, implanted, like piles, into the coarse osseous substance of the jaw. Often-

FIGURE 237

Lower jaw of haddock (Tomes). *a*, bone of jaw; *b*, bone of attachment; *d*, dentine of tooth.

times, the tooth substance is more dense than the jaw bone. Teeth implanted in sockets are found in the Barracuda pike, the filefish and other species. These teeth are developed and shed continuously, as in other classes.

The Number of teeth varies widely from the edentulous fish upward. The sturgeon is without teeth as are also the pipe fish and sea horse (hippocampus). In some of the lower types (the glutinous hag) a single tooth

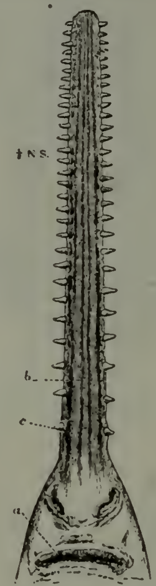


Figure 238

Rostrum and under side of head of a small pristis (Tomes). *a*, mouth; *b*, rostrum; *c*, one of the rostral teeth.

developed on the median line of the palate represents the dental system. In the carp, a single median tooth above the pharynx opposes two dentigerous plates below. In the ceratodus, the jaws have four teeth, two above and two below. From these types are traceable every gradation in the progressive multiplication of the teeth, up to the pike, silurus, and other types, where the mouth contains many teeth.

The Medullary Canals, or tooth pulps, also have undergone changes in evolution from the placoid scale. The tooth, assuming a different shape, still retains a large surface for the entrance of nerves and blood vessels. Although the attached surface has diminished in size, the inner tooth surface receives plenty of nourishment from the pulp, the largest diameter of which is at the base of the tooth. Changes in pulp size depend upon the size and shape of the tooth.

Development of fish teeth, as in all vertebrates, is produced by a single papillae from the free surface of either the soft, external integument, as in young pristis (sawfish), or of the mucous membrane of the mouth. In these primitive papillae, there can be readily distinguished a cavity containing fluid and a dense membrane surrounding the canal, itself covered by a thin, external buccal membrane which becomes thinner and thinner as the papilla increases in size. Some species have edentated horny plates arranged in greater or smaller rows and attached only to the mucous and fibrous membrane covering the maxillary cartilages. In others, the dental papillae do not sink into the substance of the vascular membrane. In still others, the papillae become buried in the membrane from which they arise.

In all fish types, the teeth are shed and renewed throughout life, so that they can hardly be said to possess permanent teeth. The rostral teeth of the pristis (sawfish, Fig. 238) are the only exception. They may be regarded rather as modified dermal plates.

Teeth of Reptiles

The teeth of reptiles present less diversity in shape, attachment, number and development than fish.

The Shape of reptile teeth is nearly always conical, never branching into cusps or roots at the tooth base. They may be sharp, blunt or serrated. In the carnivora, they are sharp and thin, while in the herbivora, they are blunt.

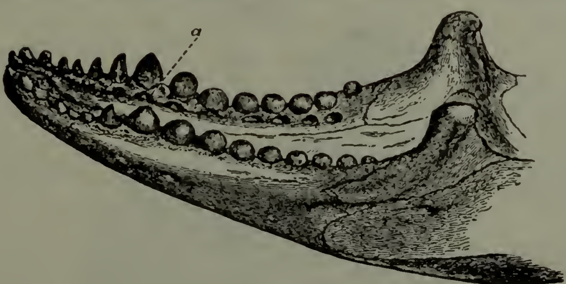


Figure 239
Lower jaw of lizard (Tomes). *a*, foramina leading to cavities of reserve.

The cartilaginous tadpole jaws possess tough, horny plates simulating the shape of a turtle's beak and also in addition, the inner edges of the lips have small horny spines or hooks each on its own individual base, which are shed before the commencement of true tooth formation.

Lizards have the greatest variety of shape, some sharp at the edges, others rounded and blunt (Fig. 239).

In the saurians, the teeth are always conical, either sharp, blunt or serrated, with vertical ridges and prominences.

Attachment. The mode of attachment of reptile teeth closely follows their destined use, governed by the habits of the type, and is similar to that of fish. Transitory human teeth bear a close analogy to reptiles.

The most common attachment of reptilian teeth is ankylosis, sometimes, however, merely in grooves, prominences, slight depressions or sockets. Saurian reptiles (lizards, etc.) have simple teeth attachment to the jaw margin.

In the extinct Ichthyosaurus (fish-lizard), the teeth were not in distinct sockets but lodged in a continuous shallow groove with little or no transverse divisions.

In the frog, the teeth are attached by ankylosis to a bony prominence for each individual tooth similar to Fig. 235.

In the Dinosauria, the teeth were set in imperfect sockets, the outer alveolar wall being higher than the inner.

In some snakes, the tooth is so firmly attached to the jaw bone that the latter might be considered a part of the tooth, since it is completely lost with the tooth and develops again for the new tooth (Fig. 240).

Figure 240

Section of tooth and portion of jaw of python (Tomes). Shows the marked difference in character between the bone of attachment and the rest of the bone.

When the tooth is ankylosed by its outer side to an external parapet of bone, the creature is said to be "pleurodont"; when by the end of its base it is attached to the summit of a parapet it is "acrodont."

In the crocodile, the most highly developed living reptile, the teeth are situated in distinct alveolar sockets and are not ankylosed to the walls.

They are situated at the margins of the jaws and are noted for their sharpness (Fig. 241).

NUMBER. Many reptiles, notably the toads, are entirely edentulous. Tortoises and turtles also have no teeth but the jaw margins have horny plates, shaped according to the animal's habits. In Rhamphorhynchus, the anterior ends of the jaws are without teeth, and it has been conjectured that these portions were sheathed in horny beaks. Prof. Marsh found several species of Pterodactyls wholly without teeth. The jaws, more like birds than reptiles, show no trace of teeth, and the premaxillaries seem to have been encased in a horny covering. Frogs have no teeth upon the lower jaw. The adult Hatteria (lizard-like reptiles) actually masticate upon the jaw bone, the teeth (rudimentary) having been worn away in early life.

In some reptiles, there are as few as sixteen teeth in the upper and fourteen in the lower jaw. In certain batrachians, there are eighty in

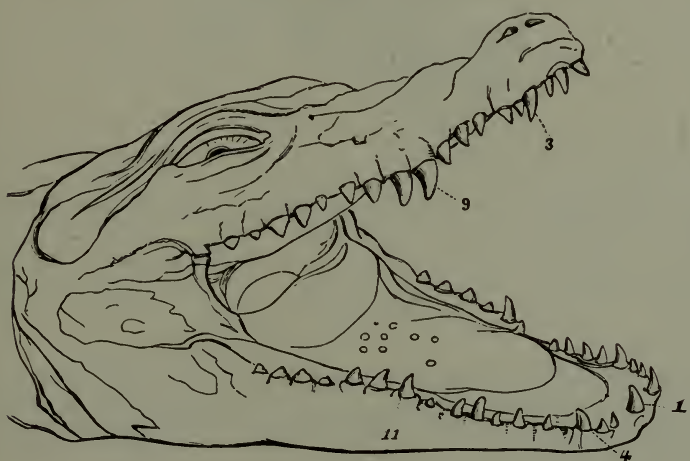


FIGURE 241

Jaws of the crocodile (Tomes). The first, fourth and eleventh teeth in the lower jaw and the third and ninth in the upper are seen to attain to a larger size than the others.

each lateral maxillary. The teeth in the different species and genera differ from each other in number. Some have sixty-six, others sixty-eight, some seventy-six and still others one hundred and eighteen.

THE MEDULLARY CANALS, or pulps of the teeth of reptiles, are not unlike those of fish. Beginning with the broad surfaces of the plates and horny teeth, in which the entire surface furnishes nerves and blood vessels for their nourishment, the canals change with the change in the shape of the tooth. These pulps extend into the tooth substance, but always remain

largest and broadest at the base, as observed in the crocodile. In all sauropsidae, the foramina are large (Fig. 242).

Development. In the development of reptilian teeth, a period occurs when the primitive dental papillae are not protected by either an outer or inner alveolar process. In another stage, the groove containing

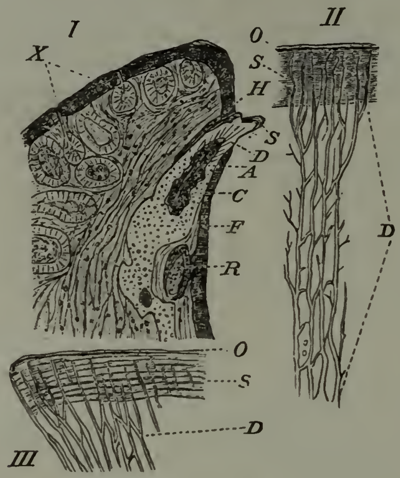


Figure 242

I. Section of premaxillary bone of reptile showing attachment (Hertwig). Magnified 22 times. II. Dentine and enamel, magnified 500 times. III. Enamel, magnified 500 times. *A*, Blood vessel of the pulp cavity. *C*. Crusta petrosa. *D*. Dentine. *F*. Processus dentalis. *H*. Layer of epithelium. *O*. Tooth cuticle. *R*. Second tooth germ. *S*. enamel. *X*. Cutaneous glands.

the dental germs is protected by a single extended cartilaginous alveolar ridge, as in most lizards. Next in order of evolution there is developed an internal alveolar plate, and the sacs and pulps of the teeth sink into a deep but continuous groove in which traces of transverse partitions soon make their appearance. In the Ichthyosaur, the relation of the jaws to the teeth advances beyond this stage. Finally the dental groove is divided by complete partitions and separate sockets are formed for each tooth. This developmental stage is attained in the most highly organized reptiles, represented by the crocodile.

In crocodile tooth development, absorption of the roots of the first teeth takes place, allowing the second to take its position. The number of teeth does not change. The young crocodile possesses as many teeth as the adult. The development of a new tooth precedes the absorption of the older tooth root (Fig. 243). In this manner, there is a tooth succession throughout the life of the animal.

The jaws and teeth of fish and reptiles are of interest, since, as has been already shown, one form of degeneration of the human jaw, the V-shaped dental arch, assumes these types.

FIGURE 243
Section of jaw of young alligator (Tomes). *A*, oral epithelium; *b*, bone of socket; *d*, dentine of old tooth; 2, tooth next in order of succession which is causing absorption of one side of the base of the old tooth; 3, young tooth germ.

Teeth of Extinct Birds

"Birds," says Prof. Huxley, "are animals so similar to reptilia in all the most essential features of their organization, that they may be said to be merely an extremely modified and aberrant reptilian style. Their

FIGURE 244
Head of extinct bird. Natural size. (Dames). Shows individual cone-shaped teeth.

differentiation is, however, so great as to indicate without doubt, their rights to form a distinct class."

Since birds belong to the same group as reptiles (sauropsidae) it would be strange if the teeth of both did not resemble each other.

Many years ago, Geoffroy St. Hilaire described a series of vascular pulps on the margin of the jaw of parakeets about to be hatched which, though destined to form a horny bill and not to be calcified into teeth, strikingly recall dental pulps. The famous fossil bird of the lithographic shale of Bavaria had a long jointed tail and possessed teeth (Fig. 244). Up to the discovery of this bird's head, toothed birds had been unknown. Later, however, Prof. Marsh found nine genera and twenty species. They are referable to two widely different types. One group consists of a very

FIGURE 245

Skeleton of the Hesperornis regalis (Marsh). The long bony tail shows a relationship to the reptilian type. The teeth are not unlike those of reptiles. The undeveloped wings show that the bird was a diver.

large swimming bird without wings, having teeth in grooves (Odontocae type, genus Hesperornis). The other group consists of comparatively small birds with great power of flight and having their teeth implanted in distinct sockets (Ondontotornae, of which the genus Ichthyornis is a type).

The genus Hesperornis (probably diving birds, Fig. 245) includes species six feet in length. The teeth are not implanted in distinct sockets, but lie in a continuous groove like those of the Ichthyosaurus. The slight projection from the lateral walls indicates a partitioning off into sockets, but nothing more than this is attained, and after the soft parts perish, the teeth are easily displaced and had often fallen out of the jaws. The premaxillary is edentulous, but the teeth extend quite to the anterior extremity of the lower jaw. In one specimen, there are fourteen sockets in the maxillary bone and thirty-three in the corresponding lower jaw.

The successional tooth germs formed at the side of the base of the old ones and caused absorption of the old roots. They migrated into the excavations so formed, grew large and ultimately expelled their predecessors (Fig. 246). In structure, their teeth consisted of hard dentine,

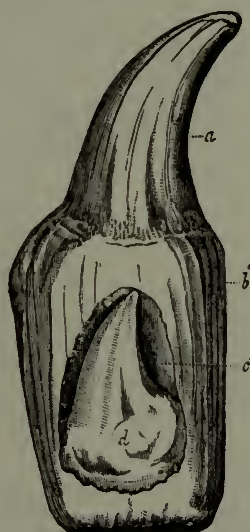


FIGURE 246
Tooth of Hesperornis regalis (Marsh). Enlarged eight diameters. The successional tooth is immediately underneath, producing absorption of the tooth above.

invested with a rather thin layer of enamel and a large axil pulp cavity. The basal portion of the roots consists of osteodentine. The outer side of the crown is nearly flat, the inner strongly convex. The junction of these surfaces is marked by a sharp unserrated ridge.

In Ichthyornis (Fig. 247) the teeth were about twenty-one in number in each jaw, sharp and recurved. The crowns were coated with enamel. The front and back edges were sharp but not serrated. They were implanted in distinct shallow sockets but the maxillary teeth were a little larger than those opposing them. The premaxillaries were evidently edentulous and perhaps composed of a bony bill. In the lower jaw, the

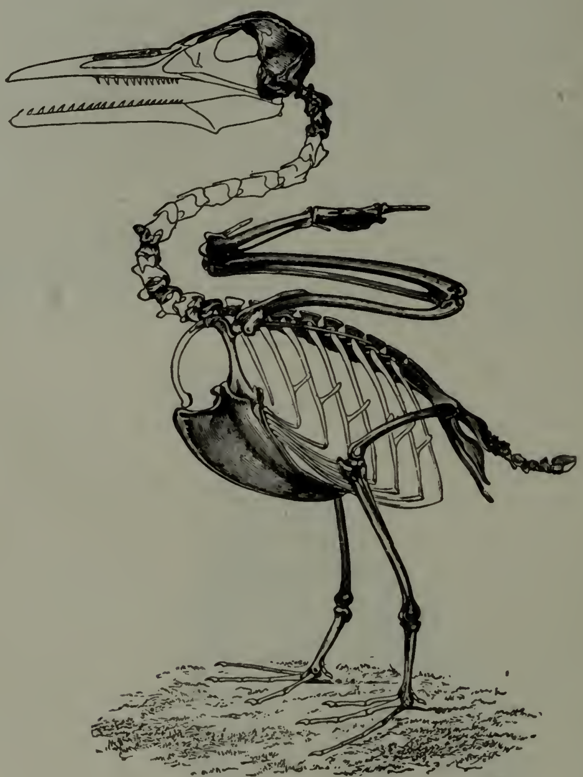


Figure 247
Skeleton of Ichthyornis victor (Marsh). Although the tail is made up of bony joints, it is shorter than the previous illustration and possessing wings and short legs shows a much higher type of bird. The teeth are specialized with single cones and separate sockets.

largest teeth were about at the center, those at the posterior end being smaller, the sockets deeper and stronger than in the upper. Tooth succession took place vertically.

According to Prof. Marsh, the main features of the teeth of the Hesperornis are characteristically reptilian. One of the earliest of these fossil birds, the Archaeopteryx, is a remarkable combination of bird and

lizard. Unlike any modern bird, the jaws were provided with many conical reptile-like teeth situated in distinct sockets.

With these notable exceptions, the jaws of all known birds are toothless, the horny cases forming their beaks taking the places and fulfilling the functions of teeth.

The relation which the horn cone bears to the dental papilla and its dentine is entirely different from that borne by the horny teeth of the ornithorhynchus, whose horny plate lies beneath the teeth. This is a phenomena of evolution by atrophy through which structures disappear, by the law of economy of growth, for the benefit of the organism. The evidences that true teeth may become replaced by horny teeth, these again coalescing with their neighbors to form a horny casing, have been set forth.

It would seem, then, that the precursors of birds had true teeth. It is probable that a sufficiently extended search will reveal rudimentary teeth surviving beneath the functional horny bill, or even above it, like those of the ornithorhynchus. Indeed, Rose has found that in Sterna the tooth band exists, although no rudiments are to be found of tooth germs.

Teeth of Mammals

In all essential characters by which mammals are distinguished from other vertebrates, such as possessing warm blood, breathing air by lungs, bringing forth their young alive and nourishing them for a time with milk, they agree with other members of their class.

All mammalian dentition consists of a definite set of teeth, nearly always constant and of determinate number, form and situation. With but few exceptions, they persist in a functional condition throughout the animal's life. In many species, the animal possesses only one set of teeth, the set first formed being permanent, or, if lost, never replaced. No mammal has, normally, more than two sets of teeth. When the first teeth are well developed and continue in place during the greater part of the animal's growth (as is especially the case with the ungulata and to a lesser degree with the primates and carnivora), the use is obvious, since they form, structurally, a complete edition on a small scale of the more numerous and larger permanent set. Those animals, therefore, that have well developed and tolerably persistent first teeth may be considered in a higher state of dentition development than those that have the first set absent or rudimentary.

Mammal dentition is of two kinds. In some few forms, known as "homeodont" all the teeth are of one type or pattern; for example the sloths, armadillos, dolphins, etc. The remainder, or "heterodont" mam-

mals, forming the great majority, are provided with teeth of several different types. In the dog's skull (Fig. 248) the three small teeth fixed on each side in the premaxilla (pmx) are the incisors, or cutting teeth (l); next follows a long and powerful tooth, known as the canine (c). Behind this there are four cutting edged premolars (pm), and two flattened true molars (m). In the lower jaw, the same tooth types are represented, there being in the dog three incisors, one canine, four premolars and three molars. Tooth numbers vary greatly in the different mammal orders.

A second mammalian dental division is, in some few forms, chiefly "homoedont," where there is only a single set of teeth, while in others a permanent set is preceded by an earlier temporary one, only present during

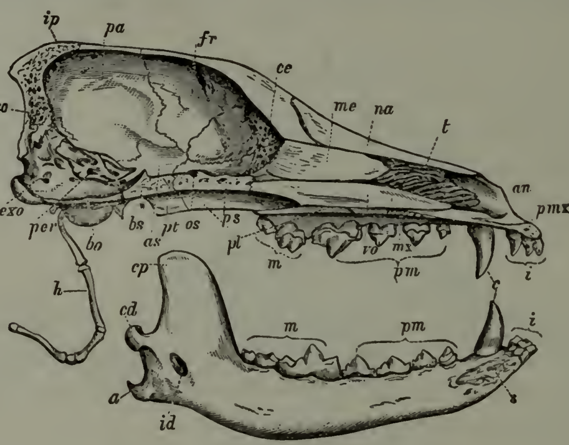


Figure 248
Skull of dog divided down the center to show internal structure (Sir W. H. Flower). *i*, three incisor teeth making six on each jaw; *c*, canine teeth; *pm*, premolars; *m*, molar teeth.

the period in which the young animal is nourished by milk, although its duration does not always coincide; the temporary teeth, in some instances, are shed or absorbed by the time the animal is born.

The teeth belong, essentially, to the dermal organ system, passing from hard spines and scales upon the integument covering the outer surface of the body in the lower vertebrates. In mammals, they are specialized, limited in localities, and imbedded in the alveolar process bordering on the upper and lower jaws.

The Monotremata (lowest mammals) lay eggs, have a cloaca, and are without nipples, the milk exuding from pores in the skin. The temperature is lower than other mammals. Recent observations show that the temperature of the echidna stands only at about seventy-eight degrees, some twenty degrees lower than man, and about thirty degrees below the

average bird. The study of these animals is interesting, since they form the connecting link in tooth development and other states between the cold and warm blooded animals. The skull is long and depressed; there is a large, rounded, brain case with thin walls, as in birds. There are no true teeth in adult life. In the young duck-bill (ornithorhynchus paradoxus) are three flattened saucer-like teeth in each half of the jaw, which are shed and replaced by projections or cornules. The adult duck-bill (ornithorhynchus paradoxus, Fig. 249) has a broad flat rostrum, forked in

FIGURE 249

The Ornithorhynchus or Australian duck-bill (British Museum Guide to Mammalia). An egg-laying mammal with pouches. There are no true mammae, the milk oozing from the pores of the skin. It first has teeth, afterward horny plates develop.

front, which supports the beak and in which the teeth first, and later the cornules, are implanted. In the echidna the snout is long, narrow and toothless, forming a long tube for lodgement of the tongue, as in the true ant-eater (echidna acaleata, Fig. 250). In the proechidna, the snout is

FIGURE 250

The common Echidna or Ant-eater (British Museum Guide to Mammalia). It has a long, narrow snout without teeth but plates with horny spines serve their place.

nearly twice as long as the brain case. The palate of the echidna is covered with rows of horny spines which scrape the ants off the tongue when it is drawn into the mouth. The ornithorhynchus muzzle resembles a duck's bill and is provided with cornules that take the place of the true teeth. The upper teeth have broad-topped crowns with two long cusps on the inner edge, and a serrated border along the outer edge with many small cusps. On the lower, this is reversed. They have low, broad crowns with short stunted roots, which are for a time rather firmly held. They are on the top of the horny plates. The expanded crowns narrow rapidly at the neck and are surrounded by a very dense, thick epithelium, almost horny, that rises into a ring around them and dips underneath the expanded portion so that the crown lies in a special cup of horny consistency.

This cup is not complete at the bottom, but the roots pass through it and fit bone depressions perforated by the foramina for vessels and nerves. When the animal is about twelve inches long, the teeth are shed and horny cups grow in, underneath, and become complete. The peculiar carved horny plate surface has its form determined by forming the bed for a tooth with several roots. Although the horn grows underneath and fills up the holes for the roots to go through, yet the old form is maintained by the horny plate, which henceforth serves for mastication.

Horny plates are not to be considered as horny teeth, for they are epithelial structures, that take the place of teeth. They are, hence, not closely homologous with the horny teeth of lampreys and myxincids (hags). The true teeth consist of a body of dentine with a central pulp capped with thin hard enamel and implanted by short roots, the breadth of crown exceeding its certical dimension. The enamel is of simple structure. The dentine is permeated by the fine dentinal tubes with a number of interglobular spaces, which partly covers the tubular structure of the crown. In the principal cusp apparently vascular canals exist. Toward the stunted roots a somewhat abrupt transition in structure takes place. All dentinal tubes disappear and large lacunae appear. The roots are of softer, coarser material than the crown, which is itself not a high type of dentine structure. The root type of the ornithorhynchus (duck-bill) and that of the hesperornis (extinct toothed bird) resemble each other.

The Cetacea are water animals. Outwardly they resemble fish, but their entire structural organization places them in the mammalian class. They have mammae; they breathe by lungs; they have a heart with two ventricles and two auricles. Instead of being organized for living on land, like mammals, they are admirably adapted for the water. Their body, more or less pointed, terminates in a broad transversal fin-like tail, unlike the vertical tail of fish. The tail is the principal agent in locomotion. On the back of most cetacea there is a dorsal fin which is

only a skin modification. The cetacea have no posterior limbs; their anterior limbs are swimming paddles, of comparatively little use for locomotion and merely act as ballast. Their anterior limbs are essentially of the same structure as the corresponding limbs of other mammals; namely the bat's wing, the dog's paw, man's limbs. Prominent in this order are the whales and dolphins.

Whales may be divided into two classes, Odontoceti, or tooth whales, and Mystacoceti, or baleen whales. One important anatomic character is that the Odontoceti have no baleen, or whalebone, but possess teeth which are sometimes numerous, sometimes few or quite rudimentary in size and function.

The narwhal present the most peculiar dentition of any mammal. In the adult, there are only two teeth (cuspid), both of which lie in the upper jaw horizontally. In the female, these remain permanently hidden in the jaw bone so that this sex is practically edentulous; in the male, however, the right tooth remains similarly concealed and abortive, showing the law of arrest of development and compensation. The left is excessively developed, often equalling in length more than half the animal and projects horizontally from the head in a cylindrical form. The surface is sculptured by grooves and ridges.

The so-called "whalebone" whales (Mystacoceti) possess rudimentary teeth in early life, but they are soon lost and their places are taken, in the upper jaw, by the baleen (whalebone).

Baleen, or whalebone, is similar in development to the cornules of the ornithorhynchus (duck-bill). Each plate is developed from a vascular persistent pulp, which sends out numerous long thread-like processes that penetrate far into the hard substance of the palate. Each hair-like fiber has within its base a vascular filament or papilla and, in fact, is nothing but an accumulation of epidermic cells concentrically arranged around a vascular papilla, the latter being enormously elongated. The baleen plate is composed mainly of these fibers, which constitute the hairs of its frayed-out edge. In addition to this, layers of flat cells bind the whole together and constitute the outer or lamellar portion. The whalebone matrix produced by cornification of the epithelial covering of papilla is an epithelial epiblastic structure, morphologically corresponding, not with dentine, but with enamel. The whole whalebone plate and the vascular ridge and papilla which form it are comparable to the strong ridges upon the plates of certain herbivora. Study of the mouth of young whales prior to the cornification of the whalebone tends to demonstrate this. This is obviously a return to the placoid scale type, carried into the interior by the mouth changes. The development recalls that of the spines on the palate of the echidna.

The Sirenia (manatees and dugongs) are herbivorous water mammals. Manatee dentition comprises two rudimentary incisors above and two below, buried under the horny plates occupying the anterior of the mouth. The animal possesses as many as forty-four molars, not, however, all in place at one time. The anterior ones are shed before the posterior come into place.

The dugong (sea cow) possesses a single deciduous tooth which appears before the incisive tusk. It is still undecided whether this be rudimentary or temporary. In either case, it is a lower vertebrate degeneration. The animal has two tusks imbedded deeply in the alveolus. In the female, the tusks (incisors) do not project beyond the gum, their pulp cavities are closed, and the investment of enamel is complete over the top of the tooth. These rudimentary abortive teeth are removed by absorption. They are covered by the dense, horny plates clothing this part of the jaw. These teeth are without function. Behind the region covered by the horny plates, the dugong has five molar teeth on each side consisting of dentine and cementum only.

Ungulata teeth vary considerably according to the animal's habits and methods of obtaining food. Prominent in this class are the ruminants. The dental formula in some of these animals is represented by three incisors in each jaw, one cuspid, four premolars and three molars, making forty-four teeth in all. The horse retains the full mammalian number of teeth. These teeth have roots imbedded in the alveolar process. In other ungulata, the incisors upon the upper jaw are either in a degenerate condition or are entirely missing. The hollow horned ruminants (sheep, oxen, cows, antelopes) and, likewise, almost all of the solid horned ruminants (deer) have this degeneration. Not a few of this group are without canines upon the upper jaw. Six incisors on the lower jaw show again the law of compensation. The upper canines, when present, are, with the notable exception of Moschus, Elaphodus, Cervulus and Hydropotes, small laterally-compressed rudimentary teeth. Their crowns are in about the same stage of reduction as the crown of horse canines, but their roots are relatively much more reduced. Hence they are often lost in dried skulls and it has generally been supposed that but few deer possessed canines at all. The roots of the teeth of the horse stand midway between those teeth which have persistent pulps without roots, like the elephant, rodents, etc., and those of mammals with perfectly formed roots. Thus the teeth of the horse possess open roots with persistent pulps until about the fifth year of age.

Rodentia dentition is represented by four incisors, two above and two below with three molar teeth on each jaw. The rodentia are characterized by want of cuspid teeth and by peculiar structure and great develop-

ment of their incisors. These teeth are large and curved, possessing persistent pulps which allow the teeth to elongate. The pulp canals are large and are the width of the tooth. They are admirably suite for gnawing, in that they have sharp, chisel-like edges, consisting of a hard outer enamel coat on their frontal surfaces which wears more slowly than the soft dentine. These teeth grow continually from their base as fast as the tips wear down. In case one be lost, the opposing tooth continues growing until it prevents the mouth's closing, causing starvation, or curves over and enters the back of the head, in this manner bringing about the animal's death.

In this mammalian class, a most extraordinary condition is observed in that the molar teeth have close roots when completely developed and do not elongate, while, on the other hand, the incisors grow with their persistent pulps. All the teeth are implanted in the alveolar process.

The Insectivora have small brains and faces, some resemble rodents and others lemurs. The galeopithecus (flying lemurs), formerly considered with the lemurs, form one group. One of their most peculiar features is to be found in the structure of their inferior incisor teeth, which is quite unlike those of any other mammal, or indeed of any animal. In both jaws these incisor teeth are expanded laterally and compressed from front to back, with a number of cusps on their summits, and those of the lower jaw have very wide, flattened crowns penetrated by a number of parallel vertical slits, so that they resemble small combs mounted upon narrow stems. Then again, the outermost of the two pairs of upper incisor teeth as well as the upper tusk or canine (which is nearly similar to the incisors) are inserted in the jaws by two distinct roots. This is a unique feature among living mammals, although the moles and hedgehogs have two roots to their upper tusks. The other insectivora are of two groups known by the molar pattern. The majority have a W-patterned crown, while others have narrower molars of a V-pattern.

The insectivorous bats have small incisors, rather large cuspids and molars of the W-pattern.

The lemurs usually have the upper incisors very small and invariably separated. In the cheiromys (aye-aye) the incisors form a single pair of large, curved teeth, growing from persistent pulps and wearing obliquely, so as constantly to preserve a sharp, cutting edge. The enamel is very much less thick, yet not altogether absent upon the backs of the upper incisors. The lower incisors, narrow from side to side and thick from back to front, are composed largely of enamel, the dentine constituting only a small part. Directly behind the incisors is a space devoid of teeth and then follow four upper and three lower teeth, not of persistent growth and having definite roots resembling the molars of many omnivorous rodents. The lower incisors are unique and of a remarkable pat-

tern. They are finely serrated and so deeply notched as to appear like combs.

The Carnivora include the strongest and most formidable flesh-eating mammals, known as beasts of prey, such as cats, wolves, dogs, bears, weazels, etc. There is another type, suited for water life, whose limbs are modified into swimming organs, namely seals and walrus, etc. All individuals of this order, though subsisting in part upon animal matter, do not live upon it exclusively. Some have added a vegetable diet in different proportions. Indeed many are more herbivorous than carnivorous. Hence variations of greater or lesser degree must take place in their alimentary tract, especially the digestive canal and dentition. These modifications form very important characteristics, whereby the various types are classified.

The dental system of the carnivora consists, as a rule, of incisors, canines and molars. There are six incisors in each jaw. The canines are long, strong, sharp, and well suited to tear the victim's flesh. There are two in each jaw, placed on each side of the incisors; there is generally a space between the incisors and canines of the upper jaw for the reception of the lower canine. The molars vary in number and form, according to the kind of food; they are divided into front molars, flesh teeth and tubercular or back molars. The front molars are usually pointed and increase in size from the first to the last; there is at least one, and four at most. These are followed by a tooth with a sharp edged crown, the largest in the whole system, known under the name of flesh tooth. The last or tuberculated molars, thus called on account of their large and flattened crown, are sometimes entirely wanting on the lower jaw, where they are always fewer than on the upper jaw.

The flesh and tubercular teeth vary, not only as to structure, but also in the act of mastication. The flesh teeth alternate in their action, like the blades of a pair of scissors, eminently fitting them to cut and divide flesh. The tuberculated molars, on the other hand, being directly opposite each other, and articulating closely, crown to crown, are well suited for grinding.

It may be inferred, then, that an animal is carnivorous in proportion as the flesh teeth are more and the tubercular teeth less developed, and omnivorous (mixed eating) when these conditions are reversed. We may, therefore, say with Isidore Geoffroy Sainte-Hilaire, "that the exact extent to which an animal is carnivorous is defined with an almost mathematical accuracy by the modifications of its dental system and especially of the flesh-teeth."

The points of special interest in this order of mammals are the prominence and size of the canine tooth—six incisors instead of four as in

man—and the shape of the jaws. As we have already seen, in neurotics and degenerates, one form of jaw (the saddle) deformity is arrest in phylogeny at the carnivora stage.

The Quadrumana (monkeys) are the highest of the mammals next to man. Their habits and physical organizations are more nearly like those of man than any of the other vertebrates. The gibbon, the orang, the gorilla and chimpanzee, the highest of the order, are only slightly inferior to the human species. From a purely anatomic viewpoint, they may be classed in the same genus.

Like man, they stand upright; are without a tail; like him, they are provided with hands; the face is without hair; the eyes are directed forward, while the internal organs and brain are similar. The throat, larynx and tongue are analogous, but they are incapable of speech.

The teeth are of the greatest interest at the present time. In some of the lower species (Galeopithecus, flying lemurs), there are thirty-four; namely, ten incisors, four canines and twenty molars. They have two incisors less above than below. The total number of teeth in the lower jaw is eighteen. The molars are studded with points like those of the insectivora. The lower incisors are directed forward and are deeply notched at their summits like the true lemurs.

The Simiadae (true monkeys) are divided into the new and old world monkeys. The new world monkeys are the marmosets and the Cebidae (those having thirty-six teeth). The marmosets have only thirty-two teeth, unlike the others which have thirty-six. They have three premolars on each side. The old world monkeys have the same dental formula as man. The anthropoid apes resemble man in their dentition. The Simiadae and Anthropoidae (except a generalized type found by Ameghino in the tertiary of Paraguay, which has rodent, insectivorous and ungulate features) are identical as to pulp with man. In all the essential points, the human teeth are not unlike the higher apes.

The Shape of mammal teeth which are of a higher order of vertebrates, depends upon their jaw situation and the special function they are to perform. The tooth shape also depends upon the food upon which the animal lives, and upon other purposes. They are incisors, canines and molars. In the carnivora, they are sharp and arranged in such a manner as to act like the blades of a pair of scissors. In the herbivora, they are flat and rough. In the insectivora, they are armed with little points which fit into each other.

The simplest form of mammalian teeth on a large scale is the elephant's tusk. It consists of a hard dentine mass, conical in shape, but during growth becomes more and more cylindrical or uniform in width; a thin enamel covering is observed upon the apex in the earliest condition but

soon disappears, a thin layer of cement covers the circumference of the tooth throughout life.

The pulp is long and the width of the tooth, is imbedded deeply in a socket in the maxillary bone, and grows throughout life. At the outer surface, it is converted into dentine which causes the tooth to elongate continuously. Sometimes, it wears away slowly. Such teeth are "rootless" and have "persistent" pulps.

The incisor teeth present many variations in shape, in order to fulfil their destined function. In all gnawing animals, they are much lengthened, somewhat curved and have sharp edges with only the front surface covered with enamel. In this class are the rodents, tillodonts, allotheriae and diprotodontic animals of prey. In pigs, the lower incisors grow horizontally upward and forward in order to obtain the roots upon which they live. The lower incisors of the lemuridous monkeys have finely serrated edges, while the sirenia have large upper incisor teeth for pulling up the water plants upon which they feed.

When an incisor tooth develops excessively in size, the remaining incisors are few, for example, many animals belonging to the proboscidian low type have no lower incisors. The complete absence of upper incisors occurs in ruminantia, dinocerata and chalicotheridae. In many edentata both upper and lower incisors fail to develop.

The canine teeth, so necessary to the carnivora for tearing their food, sometimes develop to a considerable degree, forming tusks, as in the wild boar, etc. The elephant and narwhal's tusks are elongated canine teeth.

According to Dr. Charles Ward, there are "four well-defined types of molars" in mammals, as follows:

"I. *Haplodont type.* The crown, undivided or simple. Existing toothed whales, some carnivora, edentates and certain rodents have teeth of this description.

"II. *Ptychodont type.* The crown folded on the sides, the folds frequently crossing the crown. Most rodents bear molars of this type.

"III. *Bunodont type.* Crown supporting tubercles. The molars of a few existing and many extinct ungulates, carnivores in general, and most primates, including man, are of this type.

"IV. *Lophodont type.* The summit of the crown thrown into folds of transverse or longitudinal direction. The Lophodonts comprise the higher ungulates and some rodents.

"The derivation of the bunodont from the haplodont type, by a development of accessory tubercles on the crown of the primitive tooth, and the gradual evolution of the lophodont type from the bunodont, are inferences toward which a study of the paleontological evidence inevitably leads. The highest stages of development to which the molar teeth have

attained are found among the terrestrial carnivora on the one hand and the higher ungulates on the other, both of which orders (together with the remainder of the Educabilia) are probably derived, as believed by Cope, from a bunodont ancestor, having plantigrade pentadactyle feet. In fact, the primitive bunodont type of molar characterized the mammals of the early Eocene period. But we ourselves are plantigrade, pentadactyle bunodonts."

Preiswerk classifies the molar teeth, which are found only in the mammalia, into,

1. Teeth with sharp points and edges (secodont) Fig. 251 (a).
2. Cuspid teeth (bunodont) Fig. 251 (b).
3. Teeth with straight crests of enamel (lophodont) Fig 251 (c).
4. Teeth with crescentic ridges on their crowns (selenodont) Fig. 251 (d).

An example of the molar tooth of animals which sever and tear their food, namely carnivora, marsupialia, chiroptera, insectivora. The molars

FIGURE 251
Mammalian molar forms (Prieswerk).

of the insectivora are approximately of this type. Meat nourishment is easily digested so the entire alimentary tract of these animals is simple. In carnivora, whose dental crowns are narrow and provided with sharp, horizontal edges, the intestinal canal is but from three to five times as long as the body, while the herbivorous animals possess an intestinal canal twenty times as long as their body.

An interesting point in connection with the teeth of mammals is the fact that teeth with two or more roots are developed. In the lower vertebrate classes, such is not the case.

Sir W. Flower shows that the molars are larger in the lower races, where they may occupy on the alveolar arch the same compass as in the chimpanzee. That this relation has persisted from the remotest times is evident from the fact that in the "man of Spy" the molars increase in size posteriorly to the same extent that they do in the apes, which is the reverse of what is usual in man, where they diminish posteriorly, or in a few lower races (Australians, etc), remain equal. In this palaeolithic race the premolars approximate "the relative dimensions seen in the chimpanzee," while the third molar even exceeds that of the chimpanzee, "reminding one of some of the gibbons." Thus may perhaps be explained the curious fact that, as noted by Dr. Houze, "the third molar is often as large as the others in the lower races," whereas, in Europeans, the last molar is disappearing through disuse, the jaws become contracted and orthognathism results. To this contraction are due some forms of the irregularities of the teeth in civilized man, since the small jaws cannot contain thirty-two well developed teeth. In savages, this defect seldom occurs, but supernumerary teeth have appeared among the New Caledonians, where Bertillon and Fontan have reported finding a fourth molar.

The Use of teeth in the various orders of mammals may be classed as follows:

First, in the beaver, as implements for transporting and working building material.

Second, in elephants, muskdeer, etc., as aids in locomotion.

Third, in dogs, for defense.

Fourth, in orang, narwhal, as inflictors of wounds.

Fifth, in wild boars, to defend their mates.

Sixth, in man, for speech, as ornaments characterized for age and sex, for biting, seizing and crushing food or otherwise mechanically dividing solid materials by mastication so as to prepare it for digestion in the stomach.

The Attachment of mammal teeth is not unlike that found in fish, reptiles and birds. The horny plates of the lowest mammals are situated upon the surface of the jaws with free blood and nerve supply. Ankylosis, or bone union, does not occur in mammals showing a step further advanced in evolution from fish, reptiles and birds. A vascular layer of connective tissue always intervenes. Lastly, but by far the most common teeth, are those with one, two, three or more roots implanted in corresponding distinct sockets in the jaw surrounded by alveolar process.

The Number of teeth in the mammalia is not so varied as in the lower vertebrates. To begin with the simple cone tooth, each class, fish, reptile, bird and mammal-recapitulates each step in their phylogeny.

There is, however, a gradual improvement in shape, attachment, number and development in each class from a lower to higher development.

Mammals, like fish and reptiles, include a few edentulous species. These are the anteaters, forming when clothed with hair, the genus myrmecophaga; when covered by scales, the genus manis; when armed with spines, the genus echidna.

In the felines, the tongue epithelium is thickened at the fore part of its dorsom and invests the papillae there, with hard sheaths like prickles which are analogous to the lingual teeth of certain fish and batrachians. The back of the dorsom of the tongue in the echidna is provided with horny plates, or denticles, which bruise the food against hard and prickly epithelium covering the palate.

A few mammals have the jaws provided with horny substitutes for teeth,—as the whalebone whales (Balaena and Balaenoptera) and the ornithorhynchus (duck-bill),—in the rest of the class true teeth are present.

Horny processes analogous to the palatal teeth of fish and reptiles are likewise developed upon the roof of the mouth of the great Bottlenose dolphin.

If the monotremes, edentates and whales, in which there is marked degeneration in the dentition, be omitted, there are four particulars wherein the dentition of mammals is shown to be more developed than that of other vertebrates. (1) The number of teeth is constant for the species, usually for the genus and often for the family. As man normally has thirty-two teeth, so the dog has forty-two, the anthropoid apes thirty-two, the platyrhine (flat-nose) apes thirty-six. (2) The teeth are firmer. (3) The body of dentine is divided, by a slight constriction, into a crown covered with enamel and a root enveloped in cement (bony tissue). (4) The roots are placed in separate sockets (alveoli) in the jaws, and in those cases where continuous growth is necessary, the pulp persists and the teeth as in the incisors of rodents and tusks of elephants and pigs, grow indefinitely. The teeth of the horse, the ox and many other mammals have open pulp chambers. The teeth of rodents are for a time rootless and with open chambers, but ultimately the pulps contract at the necks and cease to grow long. Such teeth are said to be rootless, or to have persistent pulps. The teeth of man are quite different. After the crowns have fully formed by calcification of the germ, the pulp, although continuing to elongate, begins to contract in diameter. A neck of slight contraction is formed and the remainder of the pulp is constricted in form at the neck. The remainder of the pulp is converted into the root in a tapering conical process, imbedded in the alveolar process of the bone, having at the extremity a minute perforation through which the vessels and nerves pass to maintain the vitality of the tooth,—a very different

state from the rodents, which have open cavities at the base of the growing tooth. When the teeth with closed foramina are worn away, the surface is never renewed. In teeth with open pulp chambers and growing pulps, the wearing surface of the teeth is replaced. The teeth of the horse, cow, ox and the tusks of the muskdeer and of the walrus have persistent pulps and are open at the base until the animal is advanced in age, when in some instances they close and the pulp ceases to be renewed.

When they have attained their position in the jaw, human teeth can never increase in length or alter their position. If they appear to do so, in old age, it is because of interstitial gingivitis which causes them to move about and gives rise to root absorption. The open cavity at the base of an imperfectly developed tooth causes it to resemble the persistent condition of the rootless tooth. The latter is, therefore, a mere primitive condition, the formation of the root being a completion of the tooth development. As is almost always the case in nature, the intermediate condition between the two forms is next met with. Thus some teeth, as the molars of the horse and many rodents, are for a time rootless and have growing open pulps, which always indicate that in such states the teeth are continually elongating (growing). Naturally the edges of such teeth wear away from use. Ultimately, however, the pulps contract at the necks and distinct roots form, and the teeth cease to grow. In consequence of their greater firmness, the mammal's teeth are not used up so fast and do not require rapid replacement. There occurs only one change, in which the teeth, present at birth or developed soon after, are replaced by the second or permanent set (diphyodont mammals). In some instances (monophyodont mammals), there is no change, the first dentition being permanently retained (marsupials, perhaps toothed whales), or the first dentition is more or less rudimentary (edentates, many rodents, bats, seals, some insectivores). Besides the two typical dentitions, traces of a third or even of a fourth may occur. A pre-temporary dentition of calcified germs, never functional, is seen in marsupials, but is rare in placental mammals. A dentition following the permanent one is outlined in many placentalia, and some of their teeth may exceptionally come into function. This condition is found sometimes in degenerates who are spoken of as having a third set of teeth. Hence, in man, it is a reversion to certain lower placental types.

The medullary canals or pulps and development of mammalian teeth will be considered under separate chapters. It will be observed that in the phylogeny of each type of vertebrates, as well as in the vertebrate class as a whole, from fish to reptile and from bird to mammal, there is the widest range of evolution and degeneration, due to environment and adaptability und erthe law of economy of growth, or use and disuse, of

structures. This great variation in vertebrate classes, and from one class to the other in shape, attachment, number, development, position and structure, becomes less complicated as we advance in phylogeny.

Summary

Fish

Degeneration of the teeth in fish, reptile, bird and mammal has been demonstrated. These changes have taken place for the benefit of the organism as a whole.

Environment has caused greater and more numerous changes in the teeth than in any other structure of the body. Most of the changes are reversions, or arrests in phylogeny, to forms in some other class or in lower vertebrates.

We have seen that dermal teeth and true teeth are identical structures which, in consequence of different positions and consequent difference in function, have developed differently.

Sharks' teeth are nothing more than highly developed spines upon the skin. They are imbedded in tough mucous membrane and never acquire bony connection.

Attachment. Teeth are attached to the mucous membrane by fibrous tissue, by bone attachment, by complete ankylosis, in grooves and in sockets.

Number. Some fish are edentulous, namely the sturgeon, pipe fish and sea horse; others have horny plates. There is traceable in the various fish species every gradation in the multiplication of teeth.

In all fish the teeth are shed and renewed throughout life. The teeth, therefore, are not permanent.

Reptiles

Reptile's teeth are nearly always conical, never branching into cusps at the tooth base. Those of the carnivora are sharp and thin, while those of the herbivora are blunt.

Attachment. The most common attachment of the teeth of reptiles is ankylosis; some, however, are in grooves, prominences, slight depressions, or sockets.

Number. Toads are edentulous. Tortoises and turtles have no teeth but horny plates. Marsh has discovered several species of Pterodactyls wholly without teeth. The jaws, which are more like those of birds than of reptiles, show no trace of teeth.

The adult Hatteria (lizard-like reptile) actually masticate upon the jawbone, the teeth having been worn away in early life.

In some reptiles, there are as few as sixteen teeth in the upper and fourteen in the lower jaw.

Medullary Canals. The medullary canals are all large.

Mammals

There are two types of dentition,—homeodont teeth, of one kind and shape, as in sloths, armadillos, dolphins, etc.; the other heterdont, the great majority of teeth being of different types, as in the dog and man.

In the second division of mammalia, there is only one set of teeth, while in other mammalia, there are two sets. The dolphins, sloths and some armadillos have only a single set of teeth.

In mammals, teeth are specialized and limited to localities, always, however, in the alveolar border. The monotremes have no true teeth. The young duck-bill has three flattened saucer-like teeth in each half of the jaw. These are shed and horny plates take their places. (A degeneration.) The echidna is toothless. It has horny plates.

There are only two teeth in the upper jaw of the adult narwhal. These cuspid teeth lie horizontally across the upper jaw. In the female, they are arrested in development and are perfectly concealed within the bone of the jaw, so that this sex is practically toothless. In the male, the right tooth remains concealed and abortive, showing the law of arrest of development and the law of compensation. The left is immensely developed, attaining a length equal to more than half the length of the animal.

The whalebone whales have rudimentary teeth developed very early in life. They early disappear in the upper jaw and their places are taken up by the baleen (whalebone).

The whalebone plates and the vascular ridge and papilla which form it, are comparable to the strong ridge upon the plates of certain herbivora.

The teeth of the manatees are composed of two incisors, above and below, which are rudimentary and buried under horny plates which occupy the front of the mouth. There are forty-four molars, which are not, however, all in place at one time. The anterior ones are shed before the posterior one comes into place.

In the dugong a single tooth makes its appearance before the incisive tusk. Scientists are undecided whether it is a rudimentary incisor or a milk tooth. In either case, it is a degenerative organ. The animal has two tusks, the greater part of which is imbedded in the alveolus.

In the female the tusks do not project beyond the gum; the pulp cavities are closed. These abortive teeth are excellent examples of rudi-

mentary teeth, and are removed by absorption. They are clothed with dense horny plates. They are functionless. The dugong has five molars in each side consisting of dentine and cement only.

In the ungulata, the teeth vary according to the habits of the animal. The dental formula in some of the earlier animals consists of three incisors in each jaw, one cuspid, four premolars, and three molars, making forty-four in all. Note that this type has six incisors, like some of the carnivora. In other ungulata, they are either degenerate or are entirely missing, as in sheep, cows, oxen, antelope, all the solid-horned ruminants (deer) also have this degeneration. Not a few of the group are without canines on the upper jaw.

The upper canines, when present, are, with the notable exception of Maschus, Elaphodus, Cervulus and Hydropotes, small and laterally compressed rudimentary teeth. The roots are small and much reduced.

The rodentia have no canine teeth. The incisors are large, curved teeth with persistent pulps. The molars have closed roots and do not elongate.

The insectivora have some molars with the W-pattern, while others have the V-pattern.

The carnivora are animals known by the name of "beasts of prey," such as cats, wolves, dogs, bears, weasels and allied animals. There is another type adapted to aquatic life, with limbs modified into swimming organs, as represented by seals and walrus. Some of this class do not live entirely upon flesh, therefore their teeth must be modified. Some of these are more herbivorous than carnivorous. Such changes would also change the alimentary canal.

The carnivora possess, as a rule, three kinds of teeth; namely, incisors, canines and molars. These vary in number and shape according to the nature and food of the animal. Some molars are long and sharp, others short and broad.

The quadrumana monkeys are the highest mammals next to man. From a purely anatomic point of view, the orang, the gorilla and the chimpanzee are in the same genera.

In some of the lowest species (Galeopithecus, flying lemurs) there are thirty-four teeth, namely ten incisors, four canines and twenty molars. They have two incisors less above than below. The molars are studded with points, like the insectivora. The lower incisors are deeply notched on the cutting edge like the lemurs.

The true monkeys are divided into the old and new world monkeys The new world monkeys are divided into marmosets, with thirty-two teeth, and the Cebidae, which have thirty-six. There are three premolars on each side. The old world monkeys have thirty-two, like man.

The Shapes of the teeth depend upon their position in the jaw and the special functions they are to perform. In fish, reptiles and toothed birds, the teeth are nearly all cone-shaped or cuspids. As we ascend the scale, the higher vertebrates (mammals) possess a variety of teeth.

In the evolution of the higher vertebrates, the cuspid teeth are degenerate in the female narwhal. They remain imbedded in the jaw; in the male, the law of economy of growth is well demonstrated in the right cuspid, which is imbedded in the jaw, while the left is unusually long, being fully one-half the length of the body of the animal. In the higher vertebrates,—the ungulata, the ruminants, the rodents and insectivora,—they are entirely wanting; they are again rudimentary in the mare, while in the stallion, they are well developed; occasionally mares have four canines, again only two in the lower jaw, all of which are imperfectly formed, showing an attempt on the part of nature to restore the teeth to their normal position; in the carnivora, they are again well developed and are a characteristic feature in these animals.

Chapter XXVI

THE PHYLOGENY AND ONTOGENY OF TOOTH DEVELOPMENT

THE phylogeny and ontogeny of tooth development are so closely related, there being only slight modifications in the different groups of vertebrates, that they will be briefly considered under one head.

The tooth germs are situated a little distance below the surface; those for placoid scales a little higher than those for true teeth. Each germ is composed of two parts; the enamel germ and the dentine germ. If we divide the mucous membrane, or skin, into two parts at the basement membrane, the upper part, or layer, of epithelium is the part from which

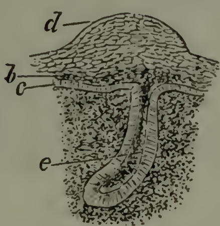


Figure 252

First appearance of tooth development (Frey). From a porcine embryo. *d*, mass of epithelium,—the "dental ridge," "maxillary rampart;" *b*, younger layer of epithelium; *c*, deepest layer—the columnar or prismatic stratum; *e*, enamel organ.

the enamel germ is derived and that below the basement membrane, the deeper parts of the mucous membrane, is the part from which the dentine germ is formed.

The enamel organ in its early stage, is formed independently of the dentine germ. The same is true of the dentine germ. It develops in a true mucosa, and is composed of nerves, arteries and veins, sometimes being called a dentine papilla. The two germs develop about the same time. If there be any priority, perhaps the enamel organ has a little the start.

The first sign in tooth development consists in an enlarging of the epithelium over the germ (Fig. 252, d). Under this swelling there is a dipping down of the epithelium into the deeper tissues. This band of epithelial tissue extends around the surface of the structure where the teeth are to grow and which will eventually become the jaw bone. At different intervals a further development of the epithelial cells and a more highly organized mass of cells occurs. This mass of cells becomes the enamel organ. There are as many organs formed as there are teeth in each jaw.

Underneath each enamel organ, there is a specialization of tissue in the true mucous membrane which eventually forms the dentine papillae (Fig. 253). The dentine papillae now become organized and take the shape of the tooth which is to be formed at that particular locality. The

FIGURE 253

A simple papillae of the mucous membrane (Kolliker). Manifold vessels and epithelium from the gums of an infant. Shows principally the cells of the epidermis. Magnified 250 diameters.

enamel papilla, or organ, now grows downward or upward to meet the dentine papillae. When they come in contact, the enamel organ moulds itself about the dentine papillae or bulb (Fig. 254) to form the enamel cap. The enamel organs, while forming the enamel caps for the milk teeth, do not remain inactive, but send out a corresponding number of connective tissue papillae, the origin of the enamel organ for the future permanent teeth (Fig. 255, h). These new enamel organs are not situated on a plane with the tooth band of the temporary teeth, but are located, as described by Rose, in the upper jaw from above backward and from below forward; in the lower jaw from below backward and from above forward. By this arrangement, the temporary teeth germs lie nearer the periphery of the maxillary surface allowing the tooth band to expand without interfering with the development of the permanent teeth. As the enamel and dentine germs begin to calicify, there is a connective-tissue envelope which encloses the entire structure in a sac (Fig. 256). The inner part of the sac, which lies directly upon the true tooth structure, is made up of loose connective tissue with numerous blood vessels, while the outer surface is composed of dense connective tissue. The formation of this sac causes the epithelial cord to become severed from the enamel

FIGURE 254

Section through the incisive portion of the lower jaw of an ovine embryo, measuring 82 millimeters ($3\frac{1}{3}$ inches) in length (Legros and Magitot). *D*, oral epithelium; *C*, lowest layer of cells in the stratum malpighii; *F*, epithelial cord; *K*, bourgeon of the secondary cord; *I*, follicular wall; *H*, dental bulb. Magnified 260 diameters.

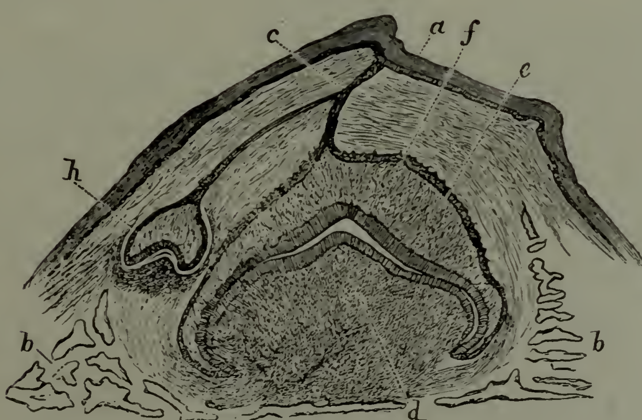


FIGURE 255

Section of upper jaw of kitten at birth (Tomes). *a*, oral epithelium; *b*, bone of jaw; *c*, neck of enamel organ; *d*, dentine papilla; *e*, enamel-cells; *f*, stellate reticulum; *h*, tooth germ of the permanent tooth, the enamel organ of which is derived from the neck of its predecessor.

organ. While the enamel and dentine germs are sojourned in this enclosed sac, the former develops the enamel and the latter the dentine in the crown.

How well this is accomplished will depend upon the nervous system of the individual. If the nervous system be stable and nutrition normal, the enamel organ and dentine bulb will develop normal and produce healthy structures. If, on the other hand, the nervous system be unstable, owing to disease in parent or child, then the deposition of lime salts will become irregular, and pits, furrows and mal-formations will occur. It is possible that the depth of degeneracy may be so great that the enamel organ or the dentine bulb or even both will not develop, in which case the enamel organ will develop the crown of the tooth without the root, as is frequently seen in degenerates and is an arrest in phylogeny at the stage of those vertebrates which possess only crowns of teeth. Again, the enamel organ may not form. The dental papillae will develop the dentine and the root will be perfectly formed. These roots will erupt into their normal position, but no crowns will present. Many illustrations are on record in which such conditions exist, an arrest in ontogeny. We frequently find in the mouths of children with an unstable nervous system, teeth with imperfectly formed enamel; its character is not unlike horn. Lime salts are wanting. Here again may be traced the law of arrest in phylogeny corresponding to the horny plates and teeth of the lower vertebrate type. Occasionally, the germs of the teeth become faulty in development and remain in sacs in the jaw. Again, we have an arrest in phylogeny simulating the lower vertebrates.

Occasionally the jaws at puberty will be edentulous; neither first nor second set are present in such persons, there is an arrest at those fish and reptile stages in which no teeth are present.

Not infrequently a number of tooth germs will not form and only a part of the dental formula will erupt in the mouth as noted in Fig. 275. Here we have an arrest in phylogeny at fish and reptile stages.

The germs of the second teeth should be located directly at the apical end of the roots of the temporary teeth, as in some reptiles and extinct birds. It is intended that these germs shall be so situated as to absorb the temporary roots while the second teeth are erupting. This, however, does not always take place. When the germs of the second teeth are located at the side of the roots, they represent an arrest in phylogeny at the stage of the fish and reptile whose teeth are continuous and develop at the sides of the previously developed teeth.

After the enamel organ has formed, the epithelial cord is absorbed a second time. At this period the connection of the epithelial cord with the mucous membrane of the mouth, its source of nourishment, should be

severed or atrophied, since there is a fixed law that continued tooth development, as observed in the lower vertebrates, does not exist in the higher. The epithelial cord, if continuous with the oral epithelium, may still bud and develop new teeth called supernumerary teeth. These supernumerary buddings may produce one or any number of additional teeth. They may be connected with either the temporary or permanent set, and may be located in any part of the jaws. Odontomes of different varieties, conditions, and shapes, are also developed at this period, in the jaws of children possessing unstable nervous system. Buddings or debris of the cord are found in the lower mammalia, such as the horse, cow, ox, sheep,

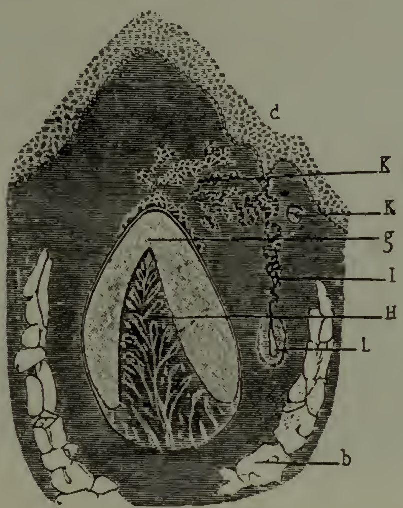


FIGURE 256

Section through the incisive region of the lower jaw of human fetus, measuring 38 centimeters (15½ inches) (Legros and Magitot). *b*, bony formation; *d*, oral epithelium; *g*, enamel organ; *H*, dental bulb; *I*, cord of the permanent follicle; *K*, debris of the follicular wall of the primitive follicle and from its cord; *K*, epithelial globule; *L*, enamel organ of the permanent tooth. Magnified 80 diameters.

swine, rabbits, guinea pigs, as well as in man. It is no doubt an arrest in phylogeny at fish and reptile stages when more than thirty-two teeth are found. If the epithelial cells remaining in the alveolar process are merely debris, of which large quantities may be found (Figs. 256 k and 257 k) in nearly all vertebrates, normal enamel organs cannot be formed for want of proper nourishment.

It is not uncommon to find extra enamel organs and dental papillae forming lateral incisors in both temporary and permanent teeth, an arrest in phylogeny at the carnivora stage.

Extra or supernumerary teeth owing to persistent enamel organs develop in the lower mammalia as well as in man. They may take the shape of the tooth adjoining, but in a majority of cases they are cone-

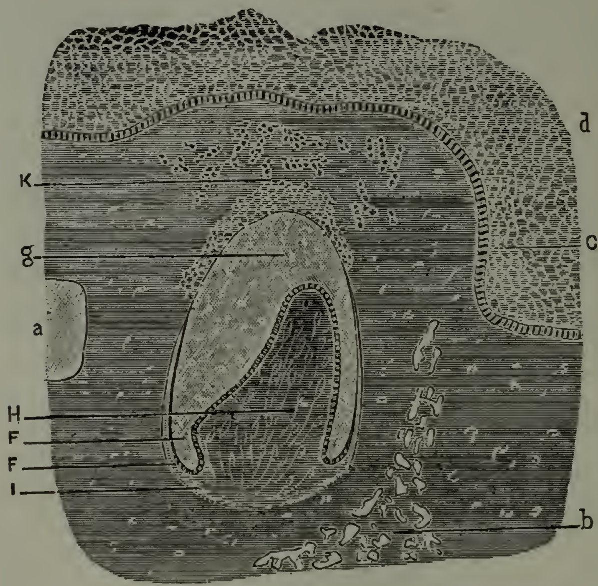


FIGURE 257
Section of lower jaw of bovine embryo showing the completed dental follicle and the surrounding tissues (Legros and Magitot). *a*, Meckel's cartilage; *b*, traces of ossification; *c*, lowest layer of epithelial cells; *d*. oral epithelium; *F*, ameloblastic layer; *F*, (lower) external layer of the enamel organ—a continuation of the layer of ameloblasts; *g*, stellate reticulum of the enamel organ; *H*, bulb; *I*, follicular wall; *K*, buddings from the cord. Magnified 80 diameters.

shaped, and are again an arrest in phylogeny corresponding to the primitive cone-tooth.

Summary

The tooth germ consists of two parts—the enamel germ, derived from the upper layer and the dentine germ, derived from the deeper part of the mucosa.

The enamel papilla grows upward or downward to meet the dentine papilla, and meeting, moulds itself around the latter, and as they calcify a connective tissue sac encloses the whole, the enamel and dentine of the

crown being there developed. At this stage the epithelial cord is severed from the enamel organ.

Under an unstable nervous system or hereditary defects, either organ may fail of development, producing a crown without a root or a root without a crown (arrest in ontogeny). The enamel may resemble horn or the teeth remain undeveloped in a sac in the jaw (arrests in phylogeny).

The germs of the second teeth, instead of being at the apical end of the first teeth, may be located at the sides, developing new teeth in that position—an arrest in phylogeny at the fish and reptiles stage.

The epithelial cord, (the medium of nutriment), instead of being severed at the proper juncture, sometimes persists and gives rise to supernumerary teeth—an arrest in phylogeny. These often occur in the lower mammals, and usually assume the form of the primitive cone-shaped teeth—a further arrest in phylogeny.

Chapter XXVII

THE ONTOGENY OF THE HUMAN TEETH

HAVING studied the phylogeny and ontogeny of the teeth in a general way, we are now in a position to study the specific phylogeny and ontogeny of the human teeth.

It has been shown that the highest perfection of the tooth, from a pathologic standpoint, consists in the cone-shape crown and root, situated some distance apart in the jaw, as observed in crocodiles, toothed birds and the lower mammalia. Single roots and single crowns prevailed in phylogeny up to the mammalian class, when the greatest struggle for existence between organs took place. As the vertebrates advanced in evolution, the great diversity of environment, such as habits, methods of obtaining food, mating and feeding their young, caused numerous changes in shape, location and number of the teeth.

The evolution of this primitive tooth to the bicuspid and molar has been explained by two theories—the concrescence and the differentiation. The first, advanced by Magitot in 1877, was later advocated by Schwalbe, Carl Röse and Kurkenthal. The last was offered by Osborn and Cope.

The Concrescence Theory is bringing together several isolated teeth and forming bicuspids and molars. A number of conical teeth in line as they lie in the jaw of the shark represent primitive dentition. In the course of time a number of these teeth would become clustered together in such manner as to form the four cusps of a human molar, each one of the shark-tooth points taking the place of one of the cusps of the mammalian tooth—in other words, by a concrescence four teeth would be brought into one so as to constitute the four cusps of the molar crown. Vertically succeeding teeth might also be grouped. Now what evidence is there in favor of this theory and what is there against it? First, there is this, that all primitive types of fish and reptiles from which mammalians have descended, and many existing mammals, as we have noted, have a large number of isolated teeth of a conical form; second, we find that by a shortening of the jaw the dental fold or embryonic fold, from which each of the numerous tooth caps is budded off in the course of development, may be supposed to have been brought together in such manner that cusps which were originally stretched out in line would be brought together so as to form groups of a variable number of cusps, according to the more or less complex pattern of the crown.

The Differentiation Theory is the addition of cusps to the conical tooth. Going back over ten millions of years in the Triassic we find the mammalia, or the first animals which we can recognize as mammalia,

possessing conical, round, reptilian or dolphin-like teeth. There are also some aberrant types which possess complex or multituberculate teeth.

"These teeth begin to show the first traces of cusp addition. In Plate A, Figures 1 and 2, the teeth of the dromatherium of the coal beds of North Carolina occur on the sides of the main cone cusps or rudimentary

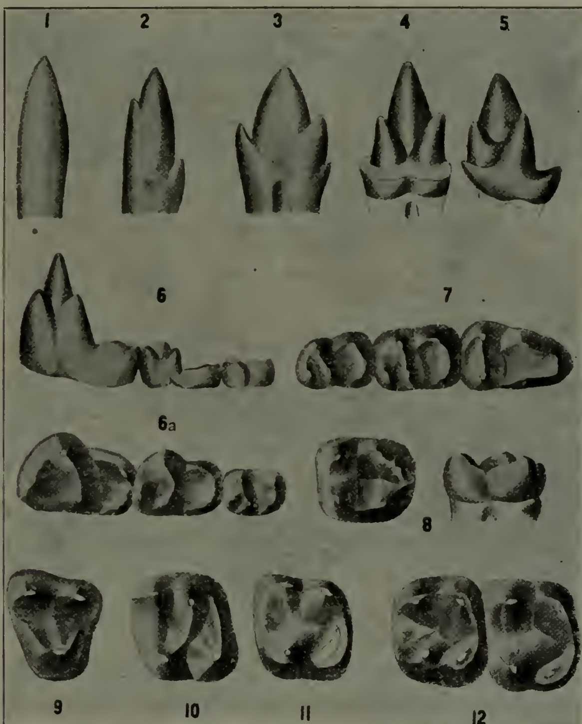


Plate A

Evolution of human tooth (Osborn). Different stages through which the tooth passes to form bicuspids and molars.

little cusps. On either side of the main cone are two small cusps. In the same deposit occurs another animal represented by a single tooth (Plate A, Figure 3) in which these cusps are slightly larger. These cusps have obviously been added to the side of teeth and are now growing. In teeth of the Jurassic period, found in large numbers both in America and in England, but still of very minute size, are observed these same three cusps. These cusps have now taken two different positions; in one case they have the arrangement presented in Fig. 258. The middle cusp is relatively lower and the lateral cusps are relatively higher, in fact, these

cones are almost equal in size. These teeth are termed triconodont, as having three nearly equal cones. But associated with this is the spalacotherium, the teeth of which are represented in Plate A, Figure 4. Here is illustrated the transformation of a tooth with three cusps in line into a

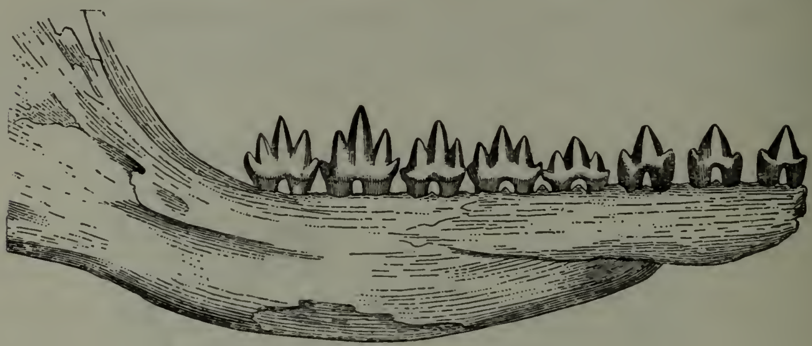


FIGURE 258
Lower fossil jaw and teeth of animal of Jurassic period (Osborn). Shows roots and cusps on a line.

tooth with three cusps forming a triangle. Here the primitive cusp is the apex of a triangle of which the two lateral cusps are the base. This tooth, in this single genus, is the key of comparison of the teeth of all mammalia, and by this can be determined that part of a human molar which corresponds with a conical reptilian tooth. This is the triangle stage, and the next is a development of a heel or spur upon this triangle (see the amphitherium, Plate A, Figure 5). The opossum still distinctly preserves the ancient triangle. Look at it in profile, inside or top view, and see that the anterior part of the tooth is unmodified. This triangle is traceable through a number of intermediate types.

"In Miacia (Plate A, Figure 6), a primitive carnivore, is a high triangle and a heel; looked at from above (Plate A, Figure 6a) the heel is seen to have spread out so that it is as broad as the triangle. The three molars of this animal illustrate a most important principle, namely, that the anterior triangle portion of the crown has been simply leveled down to the posterior portion. These three teeth form a series of intermediate steps between a most ancient molar and the modern molar of the human type, and the second tooth is half way between the first and the third. The second molar seen from above, has exactly the same cusps as the first, so it is not difficult to recognize that each cusp has been directly derived from its fellow. The third tooth of the series (Plate A, Fig. 7) has lost one of the cusps—of the triangle. It is now a tooth in which only half the triangle is left on the anterior side and with a very long heel. That tooth

has exactly the same pattern as the human lower molar (Plate A, Fig. 8), the only difference being that the heel is somewhat more prolonged. These teeth belong to one of the oldest fossil monkeys, anaptomorphus. Human lower molars not infrequently have five cusps instead of four, and the fifth always appears in the middle of the heel or between the posterior lingual and the posterior buccal. This occurs in monkeys and other animals, but no record exists of the ancient anterior lingual reappearing. The human lower molar, with its low, quadrituberculate crown, has hence evolved by addition of cusps and by gradual modeling from a high-crowned, simple-pointed tooth.

"Carl Röse has contributed considerably to our knowledge of the evolution of the teeth. He says, 'I find no mention in literature of the development of the teeth of the chameleonidae, nor of any other acrodont reptile. As the chameleon possesses multituberculate molars in the posterior portion of its jaws, therefore the development of the teeth in this animal must be doubly interesting, especially with regard to the origin of the molars generally.'

"Fig. 259 shows the teeth of the upper jaw of the chameleon five times magnified. The anterior teeth are unituberculate, the posterior one

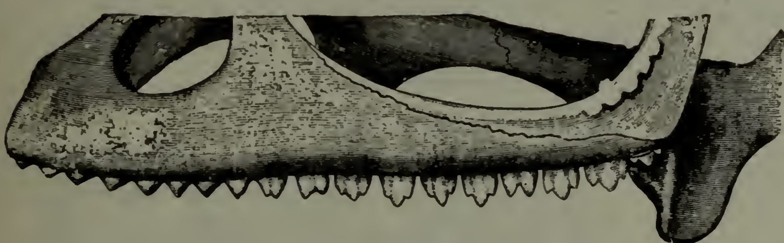


FIGURE 259
Upper jaw of a chameleon (Röse). Shows three classes of teeth conate, bi-conodont and tri-conodont. Magnified five times.

bi- or trituberculate. All teeth are fused to the edge of the maxilla. There is no shedding of the teeth in the chameleon, nor could I prove it to take place in hatteria; but still there is, especially in the upper jaw, behind the functional teeth, a well developed dental or reserve ridge. On its posterior end there takes place, throughout life, a continuous new formation of teeth. Accordingly older animals have always a larger number of teeth than young ones. Although I examined microscopically, with a lens, a number of heads of the chameleon, and microscopically six different series of sectionized jaws, I never succeeded in finding any indications of reserve teeth."

To alientists, biologists, criminal anthropologists, and sociologists the human jaw and teeth are of peculiar interest, since their study establishes many points in phylogeny and ontogeny not clearly determinable in other structures. Their study enables the observer, without much difficulty, to determine inherited and acquired stigmata. For this purpose the teeth should be studied from the first evidence of their development until they are all in place, which occurs normally, in most cases, by the twenty-second year.

Enamel of the teeth, as has been shown, is formed from the epiblast, dentine, cementum, and pulp (except as to nerve tissue) from the mesoblast. The enamel organs of the first set are formed during the seventh week of fetal life, the dentine bulb during the ninth week. At this period the tooth obtains its shape and size and calcification begins at its periphery. This models the enamel cap, which fits over the dentine like a glove. When imperfections in hand or fingers exist, these deformities are distinctly observed upon the glove. In precisely the same manner are observed the different shapes and sizes of the incisors, cuspids and molars. Calcification of the teeth begins at the seventeenth week of fetal life. Fig. 260 shows the progress of calcification and development of the temporary

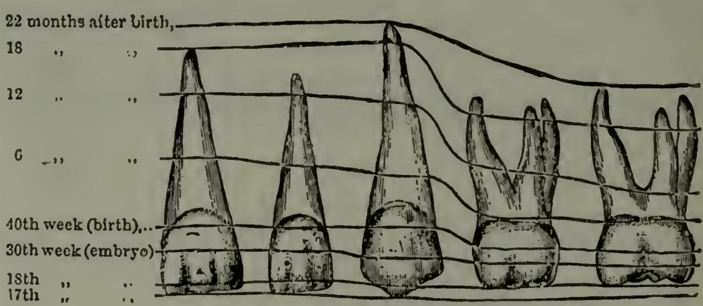


FIGURE 260
Diagram of eruption and calcification of temporary teeth (Pierce).

set of teeth. Examination will show that every defect in nutrition from conception to birth, due to an unstable nervous system, has been registered upon the teeth. The state of the constitution and the locality registers the date of such defects. Thus, if the tooth be larger or smaller than at the present stage of evolution, it is either an arrest in phylogeny or ontogeny. If, on the other hand, there be defect at any part on the crowns of the teeth, and the contour be imperfect the date of malnutrition can be easily determined by consulting this chart. More or less than the normal number of teeth, abnormally placed, demonstrate the existence of the depth of degeneracy to which the fetus has been subjected, since the

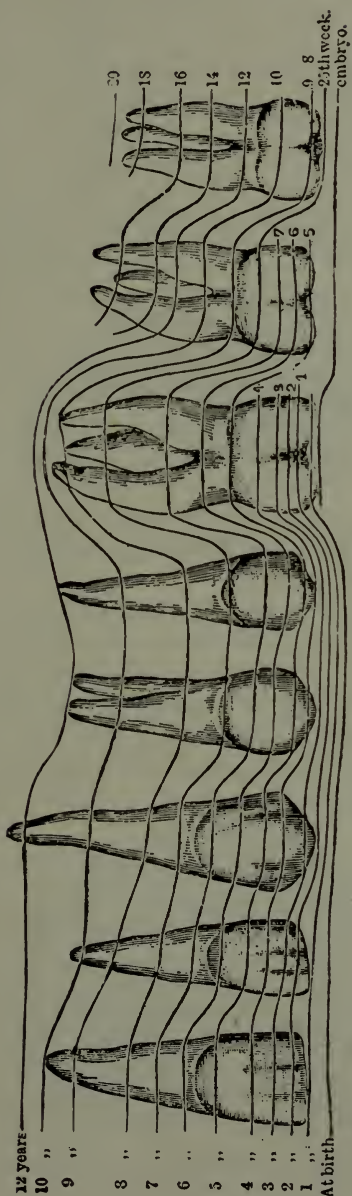


FIGURE 261
Diagram of eruption and calcification of permanent teeth (Pierce).

germs must have been deposited at the periods mentioned. No absolute rule can be laid down as to the date of the eruption of the teeth. The temporary teeth erupt nearly as follows:

	After Birth.	Time of Erup
Lower central incisors	7 months	1 to 10 weeks
Upper central incisors	9 months	4 to 6 weeks
Upper and lower laterals	12 months	4 to 6 weeks
First molars	14 months	1 to 2 months
Cuspids	18 months	2 to 3 months
Second molars	26 months	3 to 5 months

The enamel organs and dentine bulb for the permanent teeth form just before birth (Fig. 261) in like manner with the temporary set. They form just above the temporary set on the upper and below on the lower jaw. The permanent molars begin to calcify at the twenty-fifth week of fetal life. The permanent incisors do not calcify until a year after birth. Any deviation in size or contour of the permanent teeth from the normal must hence be due to defect in nutrition in the dentine bulb between the fifteenth and twenty-fifth week of fetal life. Any deviation in calcification (except the cusps of the first permanent molars) must occur after birth. At the third year, twenty-four teeth are fairly well calcified. At the fifth year the second permanent molars and at the eighth year the third molars or wisdom teeth begin to calcify.

The following table gives the approximate age of eruption of permanent teeth:

First permanent molars	6 years
Upper and lower central incisors	7 years
Upper and lower laterals	8 years
First biscuspids	9 years
Second bicuspids	10 years
Cuspids	11 years
Second permanent molars	12 years
Third permanent molars	17 to 24 years

Man at his present stage of evolution has twenty teeth in his temporary and thirty-two in his permanent set. Any deviation in number is the result of embryonic change, occurring between the sixth and fifteenth week for the temporary teeth, between the fifteenth week and birth for the permanent. The germs of teeth which erupt late in life and are (properly) called third sets, of necessity appear ere birth, and are completely formed at the beginning of the second year, although they remain protected in the jaw until late in life.

More than twenty teeth in the temporary or thirty-two in the permanent set is, therefore, an arrest in phylogeny.

From a maxillary and dental standpoint, man reached his highest development when his well-developed jaws held twenty temporary and thirty-two permanent teeth. Decrease in the numbers is an arrest in ontogeny, although it marks advance in man's evolution as a complete being. Marsh points out that in the New Mexican lower eocene occur a few representatives of the lowest primates, such as the lemuravus and limnotherium, each the type of a distinct family. The lemuravus, most nearly allied to the lemurs, is the most generalized primate yet found. It had forty-two teeth in continuous series above and below. The limnotherium, while related to the lemurs, had some affinities with the American marmosets.

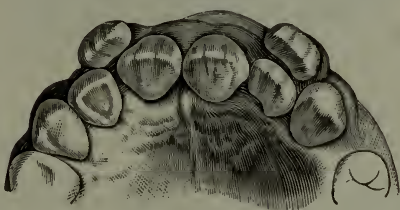


FIGURE 262
Supernumerary permanent incisors (original).

Dr. A. H. Thompson, in discussing the "missing teeth" of man, remarks that these researches of Marsh suggested and subsequent studies aided the solution of the problem of the origin of the extra teeth (known as supernumeraries) that sometimes occur in man. They are, however, excellent illustrations of atavism and demonstrate that man during his evolution from the lowest primate has lost twelve teeth." These

FIGURE 263
Supernumerary temporary lateral incisors (original). Some of the carnivora have four lateral incisors in the upper jaw.

supernumerary teeth assume two forms—either they resemble the adjoining teeth or are cone-shaped.

Supernumerary Teeth Resembling the Normal. While they rarely are exactly counterparts, every tooth can be and is duplicated, as the following illustrations show. Fig. 262 illustrates fairly well-formed duplicate central incisors, the normal incisors being outside the dental arch. They are crowded laterally by the large roots of the supernumerary incisors. Fig. 263 shows an extra right lateral in a temporary set in the upper jaw; Fig. 264 an extra right lateral in the permanent set. Fig.

Figure 264
Supernumerary permanent lateral incisors (original).

265 illustrates duplicate incisors, cuspids, bicuspids and molars. These are located in the vault of the mouth. They are normal duplicates of the regular teeth. Their location, however, is of interest since it is an arrest in phylogeny at the fish stage simulating the Port Jackson shark (Fig. 266). Fig. 267 shows supernumerary third molars, also an arrest in phylogeny

Figure 265
Supernumerary permanent centrals, cuspids, bicuspids and molars (original). Simulating the jaws and teeth of the Port Jackson shark.

at a primitive stage. The teeth, which fail to approximate their normal neighbors, assume the cone-shape of the primitive tooth.

Supernumerary Teeth—Cone-Shaped. The fact that the cone-shaped tooth, as a rule, is perfect in construction, is found everywhere in

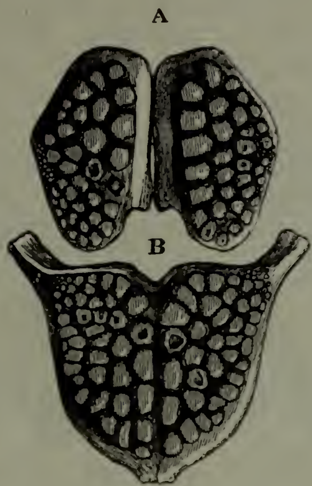


Figure 266
Jaws and teeth of Port Jackson shark (original).

the jaw, but especially in the anterior and posterior part of the mouth, is of much value in outlining tooth and jaw evolution, especially from degeneracy aspects. The upper jaw, being an integral part of the skull, and fixed, is of necessity influenced by brain and skull growth, hence degeneracy is more detectable in it than in the lower.

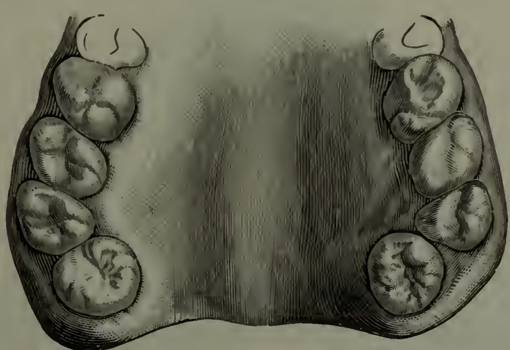


Figure 267
Supernumerary permanent third molars (original).

The evolution of the jaw is towards shortening in both directions. This shortening will continue so long as the jaw must be adjusted to a varying environment. The jaw of man having originally contained more than thirty-two teeth, lack of adjustment to environment brings about arrest in ontogeny of the jaw and atavism of the teeth due to the shortening. While this may coincide with general advances of the individual, it indicates that he is not yet adjusted to his new environment. The shortening of the upper jaw causes supernumerary cone-shaped teeth to erupt in mass at the extreme ends of the jaw. Fig. 268 shows three supernumerary teeth; a cone-shaped tooth between the central and the lateral,

FIGURE 268
Cone-shaped permanent supernumerary teeth (original).

and cuspids out of position. The left permanent lateral is at the median line, another cone-shaped tooth remains in the vault, while the supernumerary left lateral is in place. As many as eight are at times to be observed in the anterior vault. Posteriorly these teeth are most often noticed in connection with third molars, usually on a line with other teeth, posterior to the last molar. Fig. 269 shows cone-shaped molars in the

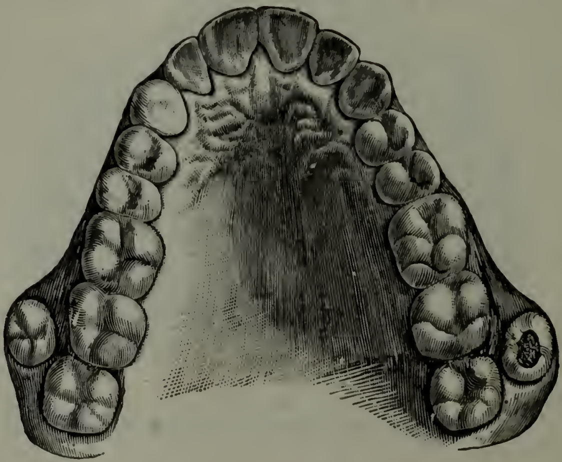


FIGURE 269
Cone-shaped supernumerary third molars (original).

posterior part but outside of the dental arch. Supernumerary cone-shaped teeth however, are not confined to these localities but may be observed at any point in the dental arch, Fig. 270. This illustration shows the

FIGURE 270
Teeth in their evolution (Smale and Colyer). The teeth show the process of evolution as illustrated in Plate A.

depth to which degeneracy may attack the teeth, only two molar teeth can be said to be normal and these are situated considerably forward of their normal position. The cone-shaped teeth are typical arrests in phylogeny, while the last two molars are fine illustrations of the arrests in phylogeny at the primitive carnivora stage (miacis, Plate A, Fig. 6). The primitive cone-shaped tooth is rarely observed in the lower jaw. In forty years' practice I have not seen a case. The mobility of the lower jaw prevents that maladjustment to environment so commonly present in the upper.

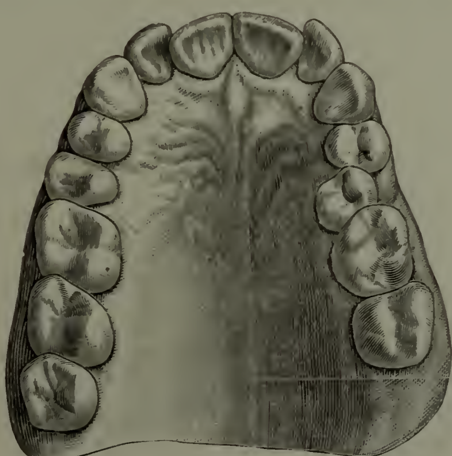


FIGURE 271
Permanent third molar missing (original).

The continual shortening in both directions of the jaw causes the third molars frequently so to wedge in between the angle of the jaw and the second molar that eruption, if possible, is difficult. The third molar is often absent in the Caucasian races. In forty-six per cent of six hundred and seventy patients, it was missing. Frequently its development is abortive. This tooth in the struggle for existence seems destined to disappear. It is more often absent from the upper than the lower jaw.

FIGURE 272
Both third molars missing (original).

When absent or badly developed the jaw is smaller, and frequently teeth irregularities, nasal stenosis, nasal bone and mucous membrane hypertrophy, adenoids, and eye disorders coexist. Fig. 271 shows absence of the left third molar with irregularities of that side of the arch,—a marked arrest in ontogeny of only one side of the dental arch. In Fig. 272, both

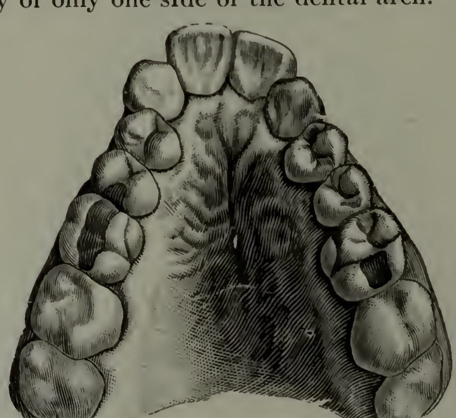


FIGURE 273
Permanent laterals missing (original).

third molars are missing, an arrest in ontogeny in both dental arches. Anteriorly the lateral incisors are most often wanting. Fourteen per cent of laterals were wanting in six hundred and seventy patients.

In the progress of evolution, some of the carnivora possess two lateral incisors upon each side of the jaw. In man, however, only one lateral incisor remains, and this tooth seems also destined to disappear. In Fig. 273 both lateral incisors are absent. Not infrequently does it occur that centrals, cuspids, bicuspids and even molars are absent. Even their germs are not detectable. Fig. 274 illustrates a cast showing three super-

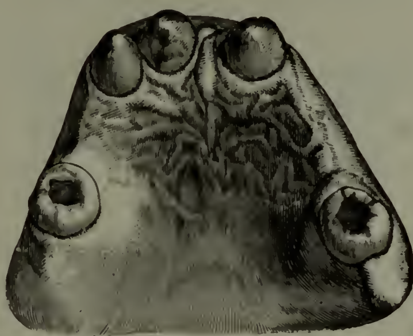


FIGURE 274
Cone-shaped teeth (American System of Dentistry). Decay taking place rapidly in the cone-shaped molars, owing to want of proper material to fill the spaces.

numeraries in the anterior part of the mouth and two cone-shaped molars, —arrests in phylogeny as to shape of teeth and arrests in ontogeny as to numbers.

The absence of teeth indicates lack of development of germs due to defective maternal nutrition.

CONE-SHAPED TEETH. Crescent-shaped bitubercular, tritubercular, as well as all deformed teeth tend to the cone-shape. The malformation of these teeth results from precongenital trophic change in dentine development. It consists in dwarfing and notching the cutting and grinding edges of the second set of teeth, a familiar example of which is seen in the so-called "Hutchinson teeth," usually referred to a syphilitic etiology. Hutchinson's position has, however, been more strongly stated than his own words warrant, since he admits that in at least one-tenth the cases luetic etiology could be excluded.

Lues only plays the part of a diathetic state, profoundly affecting the maternal constitution at the time of dentine development. While these teeth may be due to secondary result of lues, they do not always demonstrate luetic heredity, since any constitutional disease, especially those

in which dermal structures are involved will produce the same condition. The character of the malformation depends upon the severity of the disease.

In Fig. 275 are seen the teeth of an individual affected with constitutional disease, and by referring to Fig. 261 we shall see that the defective

Figure 275

So-called syphilitic teeth (American System of Dentistry). Ridges in teeth at different periods of calcification due to constitutional diseases preventing proper material from being deposited. These teeth tend to conate.

lines represent the respective ages of two and a half, four and five years. The degree of pitting depends, as a rule, upon the severity of the constitutional disorder. In the case just cited, however, although nutrition was but slightly disordered, each tooth shows a tendency to conate. The cutting edges of the incisors also take serrated forms of the teeth of the anteater and flying lemurs. Not infrequently are cavities extended completely through the tooth. The cusps of the permanent first molars calcifying at the first year are usually attacked also and arrested in develop-

Figure 276

Arrest of development of the upper jaw and bicuspid teeth (original). The bicuspids are malformed with a tendency to conate. A V-shaped dental arch is formed. The right lateral is missing.

ment, producing the cone shape. These data, together with dates of eruption of the temporary and permanent teeth, furnish an absolute basis for calculation as to excessive or arrested development. The cutting edges of the teeth take the serrated forms and are an arrest in phylogeny at the lemurian stage. Fig. 276 shows a very degenerate jaw with cone-shaped malformed bicuspids,—an arrest in phylogeny. The right lateral is missing, the cuspids are erupting in the vault, and the dental arch is assuming a V-shape. The jaw as a whole shows marked arrest in development. Fig. 277 shows "Hutchinson" teeth. Were the first molars visible they would present marked contraction of the outer surface with

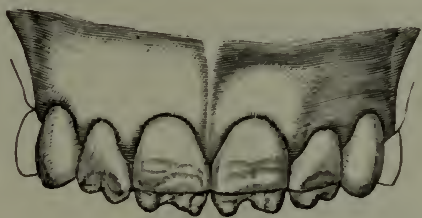


FIGURE 277

So-called "Hutchinson" teeth (American System of Dentistry). Owing to constitutional disease proper material not being furnished, the teeth conate; the center becomes notched and the enamel is badly formed.

a malformed center. Referring again to Fig. 261, we observe that trophic changes affected the system at the age of birth. Such diseases as lues and the eruptive fevers which involve the skin have a most deleterious effect upon the enamel of the teeth since those structures are derived from the epithelium. The outer surface exhibits a tendency to take the cone shape.

Figs. 278, 279, 280, 281 exhibit malformations and assume the cone-shape. The center is drawn together but there is not enough material (lime salts) to fill in and produce a perfect crown. The formation is not unlike the cranium in which gaps occur, Fig. 34. All four of these illustrations clearly demonstrate the concrescence theory of bicuspid and molar evolution. The coincidence in form between "Hutchinson" and mal-

FIGURES 278-279

Shows differentiation theory with tendency to conate (Smale and Colyer).

formed teeth and those of the chameleon demonstrates that tropho-neurotic change produces atavistic teeth. Fig. 282 illustrates the tendency of human bicuspids (when there is no antagonism) to rotate one fourth round,

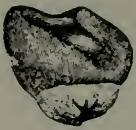


FIGURE 280
Shows differentiation theory with tendency to conate (Smale and Colyer).

thus again demonstrating the atavistic tendency toward the teeth of the chameleon. All the teeth in this illustration, including the incisors, cuspids, bicuspids and molars are arrests in phylogeny since they all tend to conate, demonstrating a marked unstable nervous system in both parent and

FIGURE 281
Shows differentiation theory with tendency to conate (Smale and Colyer). The center of this tooth has decayed from want of properly formed enamel and dentine in the center of the tooth under the law of economy of growth.

child. Fig. 283 exhibits extreme arrest in phylogeny at the sauropsidian stage. All teeth anterior to the molars are cone-shaped. The third molars are missing and would probably never erupt. This illustration

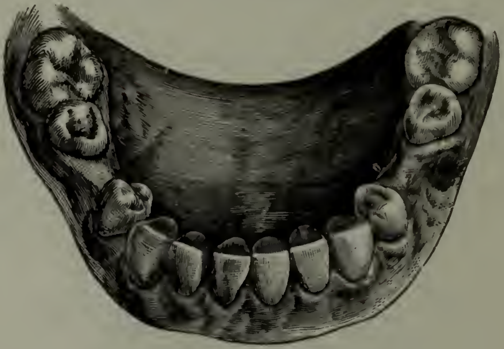


FIGURE 282
Lower jaw and rotation of bicuspids (original).

nicely demonstrates a more marked depth of degeneracy than the previous figure. In Fig. 284 appears more marked arrest in phylogeny at the

sauropsidian stage. The upper and lower anterior teeth are cone-shaped and the superior first bicuspid exhibits a tendency thereto. The right superior second bicuspid, second and third molars, the right inferior first and second bicuspids, second and third molars are missing. The same

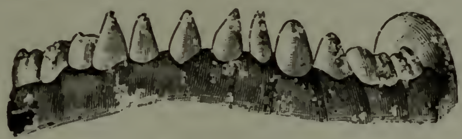


FIGURE 283
Lower jaw showing conate teeth (Smale and Colyer).

condition probably exists on the left side. The space in the upper jaw is due to the insufficient width of the teeth, and is also an arrest in phylogeny, a normal condition in fish and reptile.

TOOTH DEGENERATION AND THE DIFFERENTIATION THEORY. In degenerate jaws, the influence of the factors of the differentiation theory

FIGURE 284
Upper and lower jaws showing conate teeth (Smale and Colyer).

are also demonstrated. Every tooth in the jaw at one point or another may display rudimentary cusps. On the incisors they are always to be found on the lingual surface.

Fig. 285 illustrates the centrals with two rudimentary cusps, the laterals with one and the cuspids with one. These are arrests in phylogeny observed in Plate A. A lingual cusp on the incisor is seen in the horse (Fig. 286) which is normal. I have observed two instances, in my practice, where a lingual cusp developed on the inner surface of the incisors, (Fig. 287). This is an arrest in phylogeny as observed in the previous figure.

Fig. 288 represents cusps upon the lingual surfaces of the molars. The cuspids, which have since developed, are not unlike the lower bicuspids with a rudimentary lingual cusp.

Thompson remarks there is a gradation from central incisors towards the bicuspids in evolution. This grading of form is not observed from cuspid to bicuspid evolution in man. But we must remember that the

cuspid presents a cingulum on the lingual face that inclines it toward the bicuspid forms in lower mammals, like the mole, and that the first pre-

FIGURE 285
Upper jaw showing cusps on basilar ridge of cuspid teeth (original).

molar or bicuspid is then more caniniform, the inner tubercle being much reduced. This inner tubercle is variable and erratic as to its position. It appears as far front, as has been shown, as the centrals and is often

FIGURE 286
Section of the incisor of horse showing lingual cusp at basilar ridge (Owen).

present on the lingual face of the laterals of man. The lingual tubercle is very constant on the first bicuspid of man and is as well developed as the buccal. But in some lower forms, as in the lemurs, it is quite deficient.

FIGURE 287
Cast showing cusp on human central at basilar ridge (original).

It attains the highest development only in the anthropoids and man. Considering these stages of development, the grading from the cuspid to the bicuspid forms was more gradual in the earlier species than in the later, where the individual teeth have taken on special development.

FIGURE 288
Cast showing supernumerary cusps on first permanent molars (original).

In the skull of a degenerate girl who died from tuberculosis at thirteen years of age, among other stigmata is a cusp on the external surface of a right inferior cuspid. This is a decidedly strong point in favor of the differentiation theory. Another strong point in favor of this theory is shown in Fig. 289, where every tooth is present and a most remarkable display of cusps occurs. The cusps upon the cutting and grinding edges

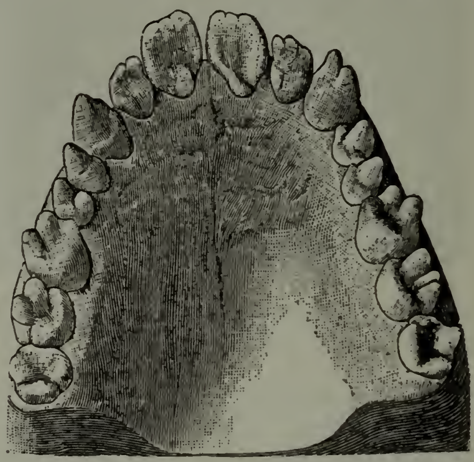


FIGURE 289
Cast showing evolution of the teeth as seen in Plate A demonstrating the differentiation theory (Smale and Colyer).

are not obliterated. Commencing with the left superior central incisor three cusps are present with a rudimentary palatine cusp. The laterals also show three cusps, while the cuspid has two very distinct—arrests in phylogeny at the lemurian stage. The illustration as a whole nicely demonstrates the entire evolution of the molar from the single cone tooth as shown in Plate A. The first and second bicuspids have tubercular cusps, they being in line. The buccal cusps upon the molars two to three are still in position. The palatine cusps have not developed. The same is the case upon the opposite except that the cuspid has cusps that have fused together, leaving a small projection upon the mesial side and a rudimentary palatine cusp. The cusp upon the third molar is lost. In the cuspids, bicuspids and molars, the prominent cusps denote an arrest in phylogeny as shown by Osborn at the early stage of tooth development. In another case (Fig. 270), the primitive cone teeth are seen trying to shape themselves into incisors. The lateral incisors, cuspids, and bicuspids are still cone-shaped. The first permanent molar is fairly formed, while the second molars are still in a primitive condition.

Tooth Degeneration and Concrescent Theory. There is abundant evidence to show that degenerate teeth unite in twos, threes, fours, and fives, as indicated in the concrescent theory. These single cone-shaped teeth grow together and form bicuspids and molars. The germs

Figure 290
Union of two central incisors demonstrating the concrescence theory (Smale and Colyer).

of any two normal teeth may intermingle and unite; not only are the crowns found united with separate roots, but crowns and roots are united throughout.

Figs. 290 and 291 show two superior central and lateral incisors joined together throughout the entire length of crown and root; Fig. 292, two

Figure 291
Union of two superior central incisors demonstrating the concrescence theory (Smale and Colyer).

lower incisors are united throughout; Fig. 293 shows a cuspid with two roots; this is an arrest in phylogeny simulating the lower mammals such as some lemurs, moles and hedge-hogs. Dr. George T. Carpenter, of

Figure 292
Union of two inferior incisors demonstrating the concrescence theory (Smale and Colyer).

Chicago, had a right superior second bicuspid with three well-formed roots; Fig. 294 illustrates two bicuspids united at the crowns trying to produce molars; Fig. 295 shows two molars perfectly united; Fig. 296

illustrates central and lateral incisors of the permanent set perfectly united; Fig. 297 shows two molars united; Fig. 298, a molar and supernumerary united, the supernumerary taking the cone-shape with deformed center. Fig. 299 shows three malformed teeth, each conated and completely united.

FIGURE 293
Union of two roots to form a cuspid tooth demonstrating the concrescence theory (Smale and Colyer).

Both these groups of single teeth united together beautifully demonstrates how roots, crowns and cusps are developed.

It is not uncommon to find three molars united as for instance the second, third, and supernumerary molar. Dr. C. V. Rosser, Atlanta,

FIGURE 294
Union of two bicuspids demonstrating the concrescence theory (Smale and Colyer).

Georgia, has two small molars and a supernumerary cuspid perfectly united from crown to root, and these three further united to the roots of a well-formed molar. Thus we see the concrescence theory is fully established.*

FIGURE 295
Union of two molars demonstrating the concrescence theory (Smale and Colyer).

*Since degeneracies of the differentiation theory and the concrescent theory are commonly found among the human race, it is possible that from the argument used in this work both theories may be partially or wholly correct.

A condition of a molar tooth occasionally observed in America, but more often in England, Scotland and Ireland, is that in which the crown is flattened from side to side (Fig. 300), and the roots nearly or quite on a line. Instead of being normal as in Fig. 301, they stand as in Fig. 302, arrest in phylogeny simulating those in Fig. 258. These teeth are generally observed in jaws of arrested development. The third or last molar, be it

FIGURE 296
Union of the inferior incisors demonstrating the concrescence theory (Smale and Colyer).

second or first, is usually affected. Sometimes more than one molar is thus involved as well as the bicuspids. This occurs in jaws where the depth of degeneracy is most marked.

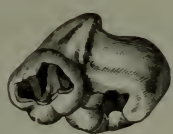


FIGURE 297
Union of two molars demonstrating the concrescence theory (Smale and Colyer).

Dr. S. H. Guilford was the first to call attention to this particular anomaly in 1887. He says, "Among the anomalies of tooth structure or formation, this one is quite rare. The crowns of this character are flattened

FIGURE 298
Three single teeth joined together throughout forming a molar tooth with cusps demonstrating the concrescence theory (Smale and Colyer).

in an antero-posterior direction, so that their diameter transversely of the jaw is by far the greater one. The fissures or sulci, instead of presenting the usual form, are distorted and sigmoid in shape, corresponding with the long diameter, while the cusps resolve themselves into narrow ridges

Figure 299
Three single teeth joined together throughout forming a molar tooth with cusps demonstrating the concrescence theory (Smale and Colyer).

somewhat after the manner of the molars of the ruminantia. The third molars of the superior arch are the ones usually affected because of their degenerative nature.

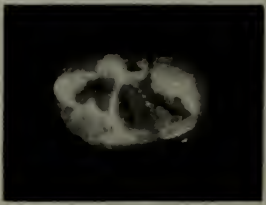


Figure 300
Malformed crown of third molar tooth (Dental Review). An arrest in phylogeny simulating the carnivora tooth.

William Booth Pearsoll, of Dublin, Ireland, also called attention to this abnormality at the 1888 meeting of the Royal College of Surgeons, Ireland. The question arose in connection with extraction, since there was difficulty in seizing the tooth with the forceps because of the shape of the crown and roots. These teeth are usually found in degenerate jaws. Like most dental abnormalities observed in degenerate jaws, these teeth are phylogenetic, reverting in crown and roots to the original "triconodont" type (carnivora) with cusps and roots in line. The roots are sometimes separated, containing two or three, or there may be only one flattened upon the sides. The pulp chamber shows the root canals also in line.

Children Born with Teeth. Children are sometimes born with incisor teeth. This is an arrest in phylogeny at the lower mammalian

(marsupial) stage. A foal is born with two rudimentary central incisors in each jaw.

Serrated Teeth. The incisors of both temporary and permanent teeth, when developed, have fine serrated edges, Fig. 303. The greater

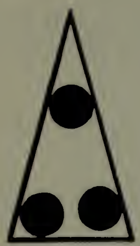


Figure 301
Diagram showing normal position of roots of molar tooth (Dental Review).

Figure 302
Phylogenic position of roots of molar tooth (Dental Review). Simulating the position of the primitive cone tooth.

the depth of degeneracy, the more marked are these serrations, Fig. 289. This is an arrest in phylogeny at the insectivora stage, but more particularly at the lemurian, Fig. 304. This is the most marked example. These

Figure 303
Cast showing serrated teeth (original). The incisors upper and lower, while erupting usually present these indentations.

serrated teeth serve to scrape the ants from the tongue. The serrations are soon worn away in the human. Six incisors are sometimes developed in the human, an arrest in phylogeny at the carnivora stage. Occasionally the lateral incisors are not developed (Fig. 303)—an arrest in ontogeny.

Non-Eruption of Cuspid Teeth. It is not uncommon to find the cuspids unerupted and lying in the vault of the maxillary bone, Fig. 305.

This is an arrest at the narwhal stage, in which the cuspids are located near the center of the upper jaw, Fig. 306. In the male, there is an arrest of development of the right cuspid, while the left is excessively developed under the law of economy of growth. The female has both cuspids arrested in development, and both are imbedded in the jaw.

Excessively Developed Cuspid Teeth. Not infrequently, the cuspid teeth are excessively developed and are prominent, with long roots,

Figure 304
Upper incisors of the Flying Lemur (Owen). These teeth are deeply notched.

an arrest in phylogeny at the carnivora stage. The saddle arch is a recapitulation of the development of the teeth in the carnivora which, owing to the small jaw, with want of harmony in the size of the teeth, could not

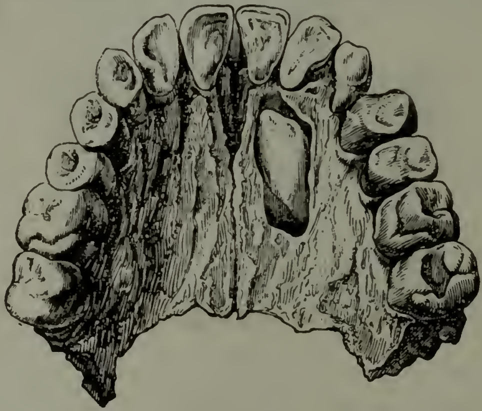


Figure 305
Cast of upper jaw showing imbedded cuspid (Salter). An arrest in phylogeny at the narwhal period.

possibly take any other form, owing to the order of tooth eruption. The prominence of the cuspid teeth give character to the human face.

Long Crown Teeth. Teeth with long crowns and very short roots are sometimes seen in children having an unstable nervous system, Fig. 307. This is an arrest in phylogeny and is found in the hysodont (having

long crowns), Fig. 308. The teeth of the early horse are shown in the smaller illustration, while that of the modern horse is a tooth with a long crown. Change in evironment, more particularly in the food, has brought

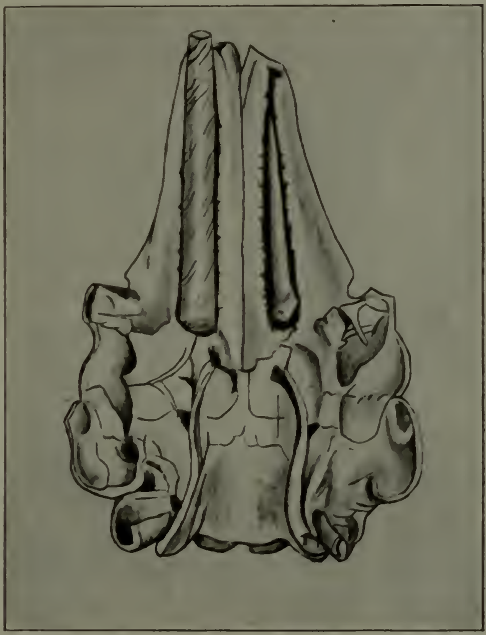


FIGURE 306
Upper jaw of narwhal (Owen). The left cuspid is arrested in development and lies imbedded in the jaw. The right cuspid is excessively developed and is more than half the length of the animal. This illustration only shows that part of the tooth imbedded in the jaw. In the female, both cuspid teeth are arrested in the jaw.

about this change. The long crown provides for a much longer period of mastication. Nature has made wise provision for erosion. Erosion in

FIGURE 307
Elongated human molar (American System of Dentistry). Simulates the molar tooth of the modern horse.

human teeth, therefore, is an arrest in phylogenetic development, a phylogenetic return to those teeth in the lower vertebrates having persistent pulps. The erosion in the human, therefore, is atavistic. The fact that the pulps in human teeth contract in root development is a degeneration.

Undeveloped and Rootless Teeth. Occasionally, teeth are seen with short undeveloped roots and again without roots. This is an arrest

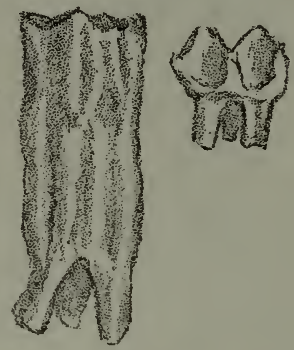


Figure 308
Elongated tooth of modern horse (Tomes). The small illustration is that of a tooth with cusps of the primitive horse.

in phylogeny which takes place at the period in which teeth are present with persistent pulps and without roots.

Teeth in large well developed jaws with large bell-shaped crowns and dense, hard, well developed enamel are an arrest in phylogeny.

Figure 309
Cast showing tooth roots without crowns (American System of Dentistry).

Crownless Teeth. Roots of teeth are occasionally seen in the jaws of defective children without crowns, Fig. 309. This arrest in ontog-

eny occurs at the very commencement of tooth development on account of a defective enamel organ or the enamel organ may not be present.

Teeth sometimes develop without enamel, or the enamel is in circumscribed areas. Sometimes the enamel is not normally calcified. These are arrests in development at the lower vertebrate type and are due to defect in the enamel organ. Each structure is an evolution in development in each class until we reach the mammal, when all are nearly alike.

Development and Eruption of Permanent Teeth. The permanent teeth should develop and erupt under the temporary, as in the higher reptiles and toothed birds, for the purpose of assisting in absorption of the roots of the temporary teeth. When, however, they develop at the sides, it is a phylogenetic arrest at the sauropsidian stage, where there is persistent eruption of the teeth. Teeth with more than one root are a mammalian feature.

Degenerate Teeth tend toward the cone-shape, a reversion in phylogeny to fish, reptile and toothed bird type. Occasionally, in degenerate jaws and teeth, especially later in life, ankylosis occurs. This is a tendency to the phylogenic ankylosis of lower vertebrate teeth. Teeth in each class, fish, reptiles, toothed birds and mammals, recapitulate themselves in most particulars and are therefore arrests in phylogeny.

Occasionally, man's second set of teeth do not develop. More commonly, however, one or more temporary teeth remain in the jaw. This is a phylogenic arrest at those vertebrate types which possess only one set of teeth.

The Molar Teeth of the anthropoid apes grow larger from before backward; in the Australian (the lowest human race) they are all of one size, while in modern races, in our present state of evolution, they diminish in size from the first molar back showing the gradual degeneration of the human teeth. Occasionally the second or third or both human molars are as large or even larger than the first. Again, an arrest in phylogeny.

Occasionally a fourth molar is found. This is an arrest in phylogeny at the primitive race stage.

When a human tooth is larger than the normal, it has usually developed at the expense of an adjoining tooth which is smaller under the law of economy of growth.

Spreading Roots. Teeth with roots spread widely apart are an arrest at the simian or higher ape stage (Fig. 310).

Supernumerary Teeth. We have shown that supernumerary teeth are an arrest in phylogeny at those vertebrates which have more than thirty-two teeth. Tomes has shown that supernumerary teeth are found in the anthropoid ape. It would be strange if they were not found in other mammalian species since in the higher mammals, the teeth are more

uniform in number. That man should be the only mammal with supernumerary teeth would not be in harmony with natural fixed laws. In all mammals, therefore, but more especially in man, since the fact has been demonstrated, supernumerary teeth are an arrest in phylogeny at the sauropsidian stage. This is further borne out by the fact that the rudimentary enamel organs, called by early writers "debris" (Fig. 256 and 257), are to be observed in the alveolar process of carnivora, herbivora and human.

Sets of Teeth. No mammal has normally more than two sets of teeth, twenty in the temporary and thirty-two in the permanent. When

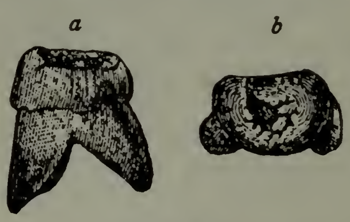


Figure 310
Third molar tooth of pithecanthropus erectus (Dubois). (*a*) side view showing short crown with distended roots; (*b*) showing surface of crown.

more than these are found, they are called supernumerary teeth and are an arrest in phylogeny. When less than this number is present, it is an arrest in ontogeny. Man, therefore, has reached his highest physical development when his jaws contain thirty-two well developed teeth.

There are, no doubt, many other degenerations of the teeth due to arrests in phylogeny and ontogeny but enough have been demonstrated to show the significance of this law.

Summary

The highest perfection in tooth development is the cone or cuspid tooth. This tooth is to be found in all classes of vertebrates. Single crowns and roots prevail up to the mammalian, when crowns change to meet the environment and more than one root is found.

The evolution of the primitive (single crown and root) tooth to the bicuspid and molar type (a purely mammalian change) has been explained by two theories: the concrescence (grown together) theory and the differentiated (changing the shape) theory. Both these theories are illustrated in the phylogeny and ontogeny of tooth development.

The calcification of the teeth takes place at nearly stated intervals, as outlined by Pierce. Man at his highest physical development has

twenty teeth in the temporary and thirty-two in the permanent set. When more, it is an arrest in phylogeny; when less, it is an arrest in ontogeny. When there are more than thirty-two teeth in the permanent set, they are called supernumerary and take the shape of the tooth adjoining, or the phylogenic cone-shape.

As man adjusts himself to the new environment, the jaws shorten in both directions. This calls for fewer number of teeth. The shortening of the jaws and the dropping of the teeth, however, do not take place uniformly, the result of which is that the third molars become impacted in the jaw. Again, the long diameter of the jaws is smaller than the long diameter of the teeth, as a result of which irregularities occur. Because of the shortening of the jaws, the teeth at either end, the third molars and the incisors, become degenerate, imbedded in the jaw, or are wanting altogether. In six hundred and seventy patients, forty-six per cent of third molars did not develop; while in the same number of patients, fourteen per cent of laterals did not develop. When we consider that in many of the lower mammals, four laterals are present in each jaw, it shows rapid arrest in the anterior jaws of the human.

In disease, especially of a marked constitutional nature and in which the skin is involved, such as lues and the eruptive fevers of children, the effect upon the enamel organ, derived from the epithelium, is most severe. The more severe the disease, the more indelible is the stamp of degeneracy upon the teeth.

It makes no difference what teeth are involved, incisors, cuspids, bicuspids or molars, the tendency of degeneracy in phylogeny is toward the cone-shaped tooth.

Tubercles or cusps may be seen on any of the teeth in the mouths of degenerate children, showing a tendency to the differentiation theory. In degenerate jaws, crowns and roots are found fused together, illustrating the concrescence theory.

Molars and bicuspids are found flattened upon the sides, and the roots are nearly or quite in rows, an arrest in phylogeny at the carnivora stage.

The incisors have serrations upon the cutting edges at the time of their eruption, an arrest at the lemurian stage.

Cusps sometimes develop upon the basilar ridges of the incisors, an arrest in phylogeny at the horse stage. Teeth are sometimes developed with short roots, again without roots, an arrest in phylogeny at the persistent pulp stage, where the teeth do not have roots. Roots of teeth sometimes develop without crowns, an arrest in ontogeny.

When the second teeth develop to one side of the temporary, it is an arrest in phylogeny at the stage where there are continuous teeth, as in the shark, some snakes, etc.

Man's second set sometimes do not develop. It is not uncommon to find some of the temporary teeth in the jaw throughout life, an arrest in phylogeny at those vertebrates possessing only one set of teeth.

When the second and third molars are as large or larger than the first, it is an arrest at the Australian stage, the lowest human type. Occasionally a fourth molar is seen, an arrest at the primitive race stage. Teeth with roots spread wide apart is an arrest at the higher ape stage. Supernumerary teeth are found in the anthropoid apes. It would be strange if they were not present in all mammals, a reversion to the fish type.

Chapter XXVIII

THE DENTAL PULP

THERE are three forms of pulp degeneration; namely, phylogenetic, ontogenetic and pathologic. The first two may be considered physiologic.

Phylogenetic Degeneration of the Pulp is a gradual evolutionary diminution in its structure from the original placoid scale and horny plate, through the various stages of fish, reptile, extinct toothed birds and lower mammals to the ape and man where the apical end of the root is nearly closed. The phylogeny in pulp degeneration, like that of root degeneration, is complete in each class above the fish type.

Ontogenetic Degeneration of the Pulp is a gradual diminution in the structure from the dentine bulb (placoid scale and horny plate stage) at the beginning of the formation of dentine to the period at which the root of the tooth has completely formed.

Pathologic Degeneration of the Pulp consists of diseases affecting the pulp tissue after it has become senile.

The Phylogeny of the Dental Pulp is not unlike the phylogeny of the teeth. The pulp of the tooth was originally the dental papilla developed beneath the basement membrane and is, therefore, dermal in its origin. It is unlike the enamel organ in that it contains nerves, arteries and veins, which the enamel organ does not. The dental papilla, in its development, shapes itself according to the shape of the structure which it eventually produces. This process varies from broad placoid scales and horny plates to the closed apical end of the tooth root.

In the teeth of fish, reptiles and extinct birds, and lower mammals, the pulps are as large as the base of the tooth, hence the teeth obtain complete nourishment. In some mammals (the tusks of elephants, the incisors of the rodentia, etc.), the teeth continue to grow and are kept alive by persistent pulps also as large as the tooth roots. Such tusks and teeth do not possess roots.

In other vertebrates, the pulps contract at the tooth neck and gradually grow smaller until at the apical end only a nerve, artery and vein enter. In each class of vertebrates, fish, reptile, extinct bird and mammal, there is a repetition of the evolution of the pulp from horny plates with surface pulps, through the persistent pulps and teeth with partially developed roots, to the nearly closed apical end where only a nerve, artery and vein enter the tooth root. The same order exists in the mammalian series.

In the lowest mammal, the ornithorhyncus, there are horny plates in the anterior part of the mouth and horny plates with teeth in the center

of the posterior part, the roots are soft and not well formed. In the advance toward the higher mammals, the pulps contract at the neck and in the anthropoid apes and man are nearly closed.

THE ONTOGENY OF THE DENTAL PULP is a repetition of its phylogeny, not only in each class of fish, reptile, extinct bird and mammal, but also from the lowest to the highest vertebrate.

Human tooth pulps are formed from the deeper layers of the mucous membrane. Their method of dentine formation was described in Chapter XXVI, "The Phylogeny and Ontogeny of Tooth Development." It was there shown that the ontogeny was not unlike the phylogeny. The pulps,

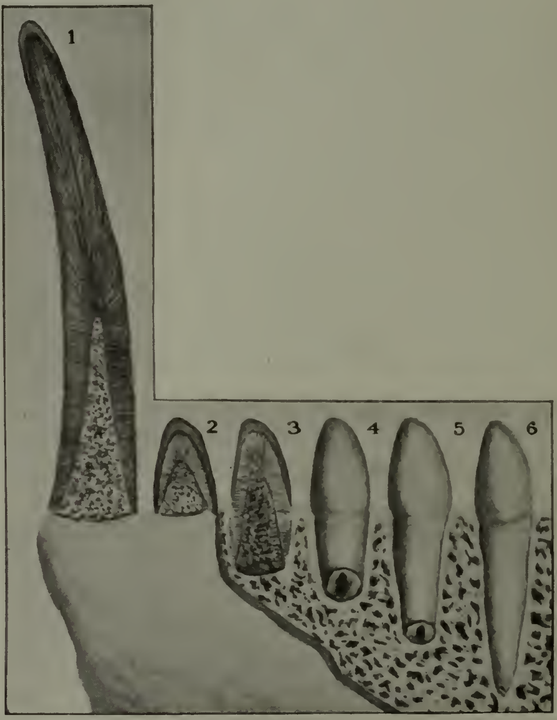


FIGURE 311

Diagram showing the phylogeny of the roots of the teeth (original). No. 1, tusk of elephant, with peristent pulp and without roots; No. 2, the crown of a cuspid tooth with the enamel and dentine perfectly formed but the root has not yet commenced to develop. At the present stage this tooth resembles No. 1. No. 3, shows the development of the root and is not unlike roots of the rodent and all teeth with persistent pulps. No. 4, shows further progression of root development. No. 5, still further root formation. Arrests in phylogeny of the human tooth may take place at any one of these stages. No. 6, shows the fully developed human tooth.

in beginning to form dentine, resemble the persistent pulps of the elephant's tusks, No. 1 compared with No. 2, Fig. 311. The pulps and their functions are the same. As soon as the dentine of the crown has formed, the pulp begins to contract, like those in single teeth of the lower vertebrates. The contraction and calcification continues as in Nos. 4, 5, 6 (Fig. 311), until the root has completely formed. Not infrequently in children with an unstable nervous system, arrest in phylogenetic development occurs at the fish, reptile or lower mammal stages, and the roots may fail to develop, as in Nos. 2, 3, 4, 5 (Fig. 311).

When the pulp has completed root formation with only a nerve, artery and vein, nourishment has nearly ceased and the tooth, so far as disease (interstitial gingivitis) is concerned, is a foreign body. It does not grow, but remains a degenerate structure in the jaw. The pulp, after root formation, becomes senile and being more or less inactive is the best illustration of an end organ in the human body. It is, therefore a fit structure to hold poisons and foreign substances circulating in the blood, for after they once enter, they have no means of escape.

The dentine of the tooth, being derived from the dentine bulb, depends upon it for normal development. In degenerate and neurotic children with unstable nervous systems, and those children who have inherited or acquired disease, the dentine bulb is apt to be abnormally developed. Again, the unstable nervous system which presides over pulp and dentine development may also produce abnormality in these structures. These abnormalities may be phylogenetic in character, such as the structures which compose the placoid scales, horny plates and the defective structure of the teeth of fish, reptile and lower mammals. Again, the dentine may become defective in its ontogenetic development. Under such pathologic conditions, defective teeth, with a want of tooth resistance to decay, are often seen.

Lymphatic and Vasomotor Systems.

Before discussing pathologic degeneration of the dental pulp, its lymphatic and vasomotor systems must first be studied. Without a knowledge of these structures, the student will be unable to understand pulp diseases.

Lymphatics. The question of lymphatics in the dental pulp is still unsettled. Sudduth, Black and Boedecker are of opinion they do exist, while Tomes, Prieswerk, Miller and others hold the opposite. I have studied the dental pulp for many years to determine, if possible, a solution of this much discussed question. From the diseases observed in the pulp it would seem almost conclusive that lymphatics are not present, while

on the other hand, Fig. 330 shows a healed abscess in a human pulp. Abscesses in persistent pulps are known to have healed; especially is this true in the pulps of elephants' tusks. While I have never been able to demonstrate lymphatics, oval spaces of different sizes and shapes occur in many pulps. In some instances they are perfectly round, but commonly flattened upon their sides without walls (Figs. 312 and 313). Their exact nature is uncertain. Researches have shown that septic material and micro-organisms have been carried from the pulp into the neck glands. Dr. Korner Halle, of Berlin, by an injection of Prussian blue into the pulp

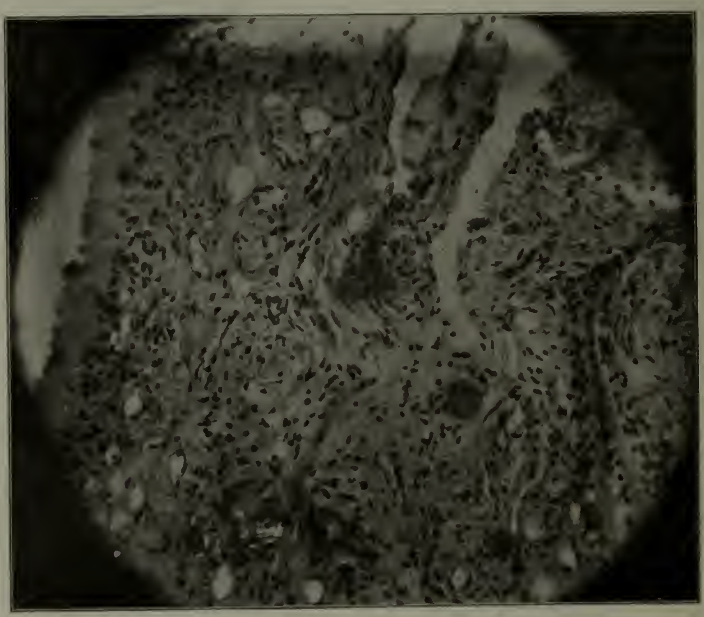


FIGURE 312
Microscopic section of the human dental pulp showing so-called lymph spaces, cut longitudinal (original). X 143.

tissue proved that the particles could find their way from the pulp into glands. He experimented upon dogs' teeth, exposing the pulp, painting it with Prussian blue and cementing the cavity. Two or three days afterwards the dogs were killed and the pulps of the teeth as well as the submaxillary glands examined with the microscope. Particles of Prussian blue were found throughout the pulp, to the apex of the root, and also in the lymph glands. This would be sufficient proof that if lymphatics are not present in the pulp, nature has provided a partial means for its care

in disease. It is certain that pulps do repair themselves, lymphatics or no lymphatics. Miller mentions a case described by Gysi, and records three in his own practice, with illustrations, in which the human pulp, after being diseased, has thrown out secondary dentine and repaired tooth decay. The pulp was restored to health. Abscesses are constantly occurring in the pulp from infection and poisons circulating in the blood stream. These abscessed areas are later restored to health, as I have demonstrated in Fig. 330.

The Vasomotor System. A study of the vasomotor system of the pulp is of interest. In no other structure of the human body is a study

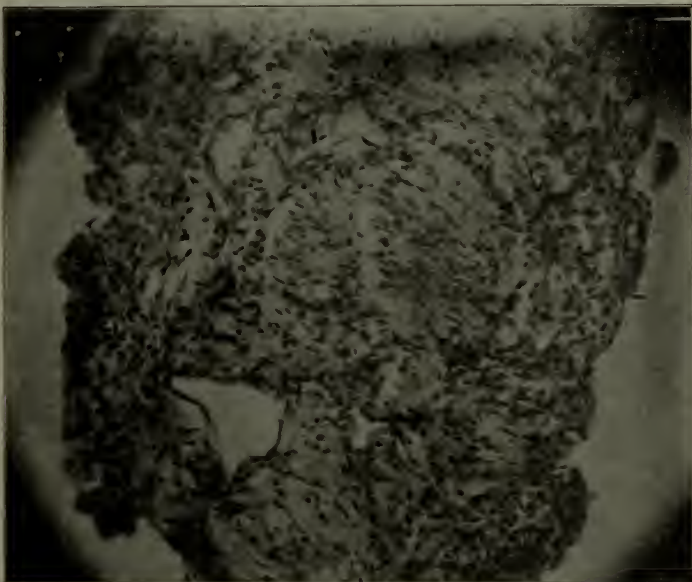


Figure 313
Microscopic section of human dental pulp showing so-called lymph spaces, cut crosswise (original). These spaces are without walls. X 45.

of the vasomotor nerves and nerve degeneration rewarded by such splendid results. Structures can here be obtained in apparently healthy persons which in other tissues of the body can only be had in disease.

The nerve trunks, in passing through the jaw, are composed of nerve fibers gathered into bundles or funiculi, called the perineurium, and are held together by connective tissue. The connective tissue, in this instance, is called the epineurium. The cut ends, under the microscope, resemble the end of an ocean cable, the wires represented by the nerve fibers, and the rubber covering by the connective tissue sheaths.

From this nerve trunk, smaller medullated nerve fibers are given off

at the nodes of Ranvier, which pass up and into the apical foramina of the roots of the teeth. Sometimes there are two, three, ten or more nerve fibers entering the foramina. The number depends on the size of the apical opening. My researches have shown that in animals whose teeth

FIGURE 314
Microscopic section of dental pulp showing nerve trunk (original). Nerve fibers torn from main nerve trunk and entering the canal through the apical foramen. X 50.

were in continuous eruption, the pulp was larger at the opening than in the pulp chamber. In man, the permanent teeth have small openings especially late in life. In the very nature of things, as man advances in age, but more especially in exostosis, the openings grow smaller. In a general way, motor, sensory and sympathetic nerves have been traced from their source to the roots of the upper and lower teeth. In no case

FIGURE 315
Microscopic section of dental pulp showing vasomotor system of nerve fibers (original). Nerve fibers encircling an artery showing terminals, X 50.

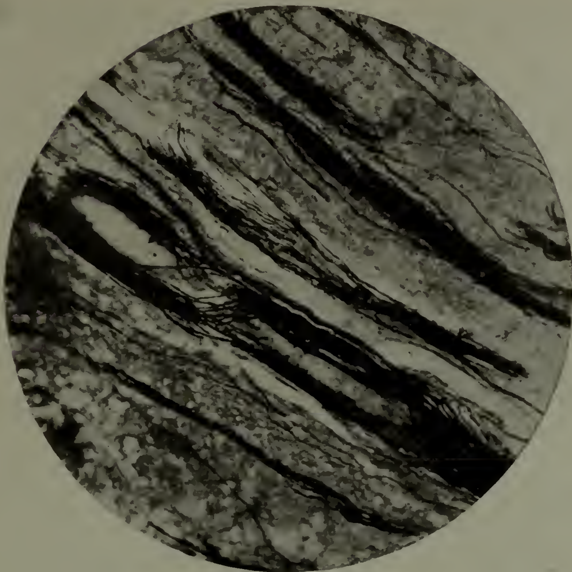


FIGURE 316
Microscopic section of dental pulp showing arteries and vasomotor system (original). Crossing of nerve fibers from one bundle to another. These extend along and around blood vessels, X 50.

FIGURE 317
Microscopic section of dental pulp showing arteries and vasomotor system (original). Nerves around a cross cut artery. Y-shaped artery in center showing terminals. X 50.

(to my knowledge) has the character of the nerves of the pulp been demonstrated.

In the preparation of the pulps to demonstrate nerve fibers and their diseases, special stains were necessary. These stains bring out the nerve tissue, leaving other tissues of the pulp very indistinct.

The nerve fibers, after leaving the main trunk in the jaw, evidently enter the apical foramina in single nerve bundles. In many instances, these nerve bundles continue the entire length of the pulp without branching. On the other hand, the branching sometimes begins after the trunk nerves have passed through the apical foramina.

In Fig. 314 when the tooth was extracted, the pulp protruded from the end of the root, the opening being large. In this illustration, the nerve fibers are shown from the inferior dental nerve extending through the apical foramina in the root canal of the tooth. They seem to run in a bundle or funiculus, with the exception of one fiber, isolated at the root.

Fig. 315 shows bundles of nerve fibers loosely arranged running in different directions. Between these bundles, may be seen many single nerve fibers running in all directions. In the center of the field is an artery, cut crosswise, with terminal fibers encircling it two-thirds around.

Fig. 316 beautifully illustrates the vasomotor nerves in their relation to the blood vessels. The blood vessels and nerves run in the same direction. In the center of the field may be seen four arteries. Nerve fibers are noticeably running the entire length between, but they cross and recross at different localities. Nerve fibers, in bundles and singly, cover the entire field.

Fig. 317 shows bundles of fibers with many single fibers throughout the field. In the center may be seen an artery, cut lengthwise branching in two directions. The most interesting item of all, however, is an artery, cut crosswise, with vasomotor terminal nerves encircling it.

Fig. 318 demonstrates the vasomotor system more thoroughly. In the center of the field may be seen nine arteries, cut lengthwise, and one cut crosswise. Bundles of nerve fibers run between the arteries and along the arterial walls. Nerve fibers are seen crossing and recrossing the arterial walls, sometimes in bundles and again in single terminal fibers. In the cross cut artery, a nerve fiber may be seen almost encircling it.

Fig. 319 shows an enlarged artery, cut lengthwise, while just below it may be seen an artery running toward it at right angles. In this artery only the outer surface is seen. In both arterial coats, terminal nerve fibers are well shown.

Fig. 320 shows the ends of the nerves cut crosswise. An artery may also be seen with a nerve encircling it.

Fig. 321 illustrates the crown end of the pulp, with a bundle of nerve

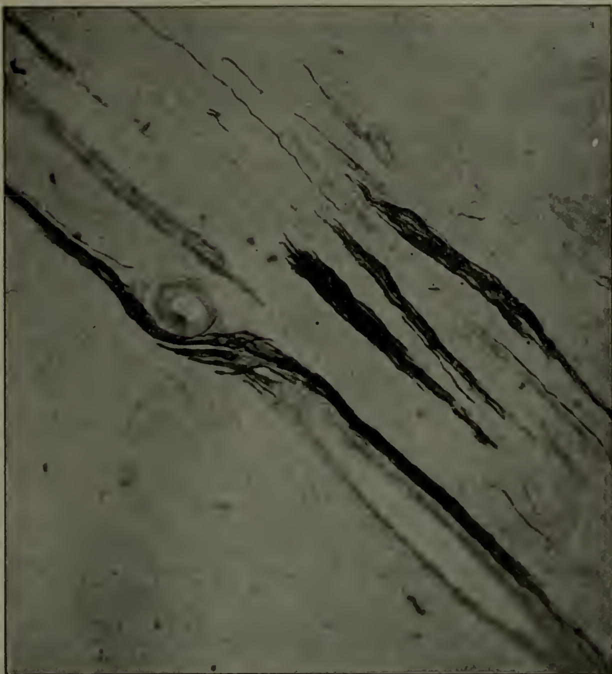


FIGURE 318

Microscopic section of dental pulp showing arteries and vasomotor system (original). Five arteries with nerve fibers running lengthwise, also cross and long section of artery with nerve fiber around it. Thickening of arterial walls showing terminal nerve fibers. X 50.

FIGURE 319

Microscopic section of dental pulp showing arteries and vasomotor system (original). Nerve extending along the arterial wall. At right angles may be seen the muscular coat of an artery filled with terminal nerve fibers. X 60.

fibers which have extended intact the entire length of the pulp, distributing fibers throughout odontoblastic layer.

Considering that the blood vessels and nerves pass through the pulp in a wavy direction and not in straight lines, the procuring of so many beautiful specimens showing so clearly and distinctly the vasomotor system is very fortunate.

Pathologic Degeneration. Beginning with the proposition that phylogenetic and ontogenetic development of the pulp from the placoid scale to its present state in adult life is a physiologic degeneracy, it is not difficult to trace pathologic degeneracy, as I have already discussed its lymphatic and vasomotor systems.

The causes which bring about diseases of the tooth pulp consist of changes in the blood stream. These changes are due to poisons circulating

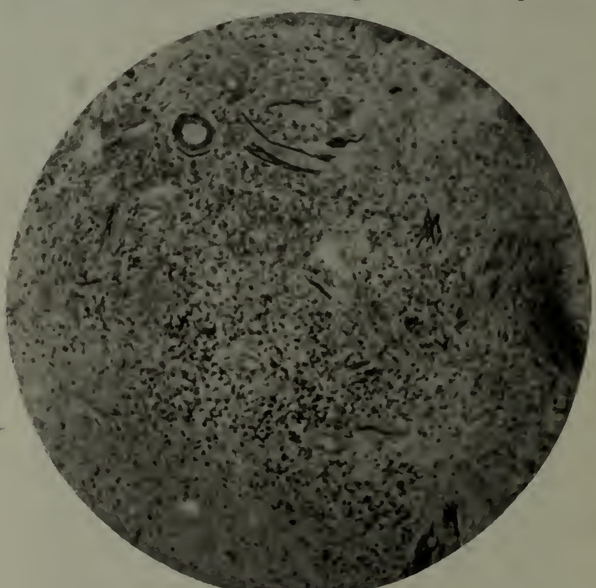


Figure 320

Microscopic section of dental pulp showing cross section of nerve fibers (original). Bundles of nerves in pulp showing vasomotor system. Crosscut section showing ends of nerve fibers also nerve encircling crosscut artery. X 25.

in the blood. The poisons are the result of degenerative conditions occurring at or around the fourth period of stress, at the senile stage, or at the period of evolution.

Not infrequently, the senile stage occurs prematurely in neurotics and degenerates. At this period, all excretory organs are weakened, resulting in faulty metabolism and autointoxication. Marked disturbances

take place in all the structures of the body, including the alveolar process (causing interstitial gingivitis) as well as the pulp. Morbid changes in the pulp, other than nerve end degeneration as already discussed, may be summed up as inflammation, abscess, nerve end degeneration, thrombosis, embolism, endarteritis obliterans, arterio-sclerosis, amyloid degeneration, hyaline, colloid, mucoid degeneration, pulp stones, fatty degeneration, neoplasm and fibroma. Some of these have been discussed by Arkovy, Tomes, Wedl, Smale and Colyer, Hopewell-Smith, Black, Boedecker, Andrews, Romer, Morgenstein, Caush, Latham and many others, and can be studied more at length in the original monograph.

It is not my intention to study each morbid condition, but to show that the pulp is susceptible to them (individually and collectively) resulting in tooth degeneration.

FIGURE 321

Microscopic section of dental pulp showing distribution of nerves in odontoblastic layer (original). Bundles of nerves in the pulp showing the nervous system. These nerves extend to the odontoblastic layer. Small fibers running below and to the odontoblasts forming a nerve plexus. X 50.

Pathologic degeneration of the dental pulp begins when it has ceased to form dentine and the apical end of the root is nearly closed. This structure, enclosed within bony walls, cannot expand and contract like other tissues when diseased, and poisons circulating in the blood give rise to many pathologic phenomena.

INFLAMMATION. The phylogeny, ontogeny, anatomy and physiology of the pulp, from its transitory and end organ aspect, render it very susceptible to inflammation.

Owing to the peculiar shape and location of the pulp, the small capillaries, and thin walls, the increase of blood pressure in the small capillaries and veins, due to irritation, is sufficient to cause rupture without the added influence of vascular changes, especially in cases of marked obstruction.

If the outflow of venous blood in a given vascular area be totally interrupted, diapedesis of the red blood corpuscles from the involved capillaries and veins starts up as a result of the local increase in intravascular pressure.

The exodus of blood corpuscles, through vascular degeneration, occurs particularly after mechanic, chemic and thermal lesions of the vessel walls; certain poisons álso affect the vessel walls with especial virulence. Claude Bernard's experiments show that dilations of the vessels follow paralysis of the local ganglia in their walls, while a disease like diabetes produces vasomotor neuroses upon end organs.

Vasomotor constriction of the pulp causes pure arterial hyperemia. Arterial dilation and redness are produced by constitutional disease or constriction at the apical foramina. As a result of this dilation, the blood current meets with less resistance in the pulp chamber and a greater amount of blood flows into it. The pressure of the corresponding capillary rises, as the blood remains under greater pressure on account of the diminished peripheral arterial resistance. It is in this manner that the capillary and venous pulsation so frequently noticed in the teeth is brought about. There is no part of the body in which local hyperemia is so apt to occur as in the pulp, since constriction is always present.

Active hyperemia produces swelling of the pulp tissue, which owing to its restricted space within the walls of the tooth, cannot expand and in the apparent absence of lymphatics, debris cannot escape. The serum of the blood transudes into the tissue, and, there being no collateral circulation, death of the pulp necessarily follows.

Local anaemia or ischemia may result from lack of blood supply in the pulp, either from constriction, disease, thrombosis of the arteries or the nerves at the apical end of the root, due to disturbance of the vasomotor system.

Narrowing of the arteries increases the resistance of the current and the blood reaches the pulp capillaries under low pressure. This causes them to contract and their surface area is materially diminished. End or terminal arteries, like those in the pulp, supply a definite organ or portion of the body and they have little or no anastomosis. They are also found in the spleen, kidney and certain parts of the brain and retina and are characteristic of end organs.

When local anaemia, resulting from constriction of a terminal artery, occurs, as at the end of a tooth root, or as a result of dilation due to the vasomotor system, death of structure or organ takes place by coagulation, stagnation, neurosis or thrombosis.

When circulatory disturbances arise, stasis takes place. When, according to Hektoen, the capillary loses all its plasma, as in local anaemia, inflammation results from constriction due to the vasomotor system, thereby closing the apical end of the tooth root. Vasomotor disturbances, producing or accelerating inflammation, have often been demonstrated. It is enough to say that any disease or action of the vasomotor system upon terminal structures (like the pulp) apparently without lymphatics, constricted at the apical end and enclosed in bony walls, is very apt to produce or hasten inflammation.

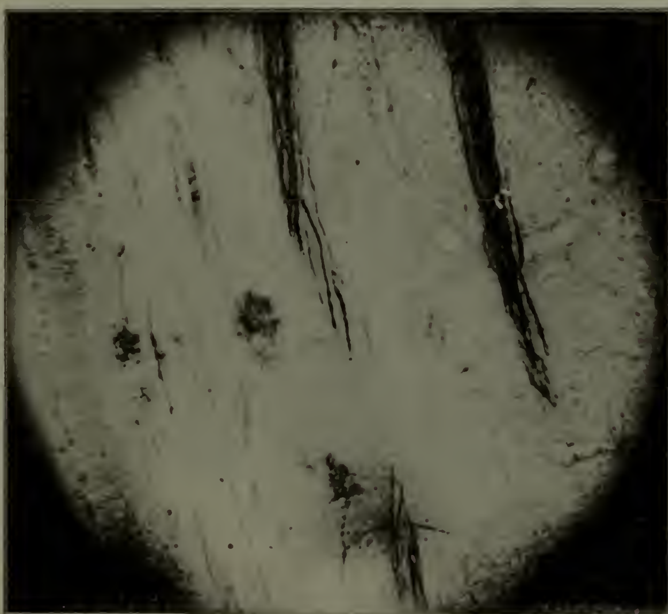


FIGURE 322
Microscopic section of dental pulp showing arteries, nerves and foci of inflammation around arteries (original). In the center above and below may be seen nerve end degeneration. X 50.

ABSCESS. Inflammation and abscess may occur at any locality in the pulp. I have observed, as will be shown, an area of inflammation with abscess at the horn, at the center of the pulp, and also in the apical end. The inflammatory process may pass through all the stages, from pus infection to abscess, without pain to the patient.

Tomes, Salter, Wedl and Harris all find that pulp inflammation may occur without exposure.

Black (American System of Dentistry) takes the student through the different processes of inflammation, where there is exposure of the organ. The same process results in inflammation of the pulp, except that the cause is internal instead of external. Whether resolution takes place or not will depend largely upon the vasomotor system, and the size of the apical foramina to allow for circulation.

Figure 322. In this section of the pulp from a molar there are in the crown some large cells (myeloid) and pulp stones, which, by much irritation,

FIGURE 323

Microscopic section of dental pulp showing arteries, nerves and foci of inflammation around arteries (original). Similar to the previous figure. The inflammation and nerve end degeneration, however, are more marked. X 156.

have caused inflammation on one side even to abscess formation, vessel dilation and a foci of red-cell infiltration. The other side is comparatively healthy, but has the round-celled infiltration showing in its very earliest condition. One, the smallest, just beneath the odontoblast layer, with well marked nerve fiber just beyond. A second, still further towards the center of the pulp on the other side of it, shows a large nerve trunk, even the internode being visible in the low power, and just above it an area of

nerve degeneration. Still lower down a darkening area of inflammation is to be seen, showing a ruptured vessel, a large number of round-cells with a small vessel or capillary shaped as a Y branching across a continuation of the lower nerve trunk. Nerve degeneration in various stages is well marked.

Figure 323 shows a similar condition to Figure 322. This area was just beneath a coronal abscess with necrosis. Cells were pushing into the connective tissue stroma and involving the arteries in some places. Just below one of the vessels cut nearly to the endothelial coat is a circumscribed

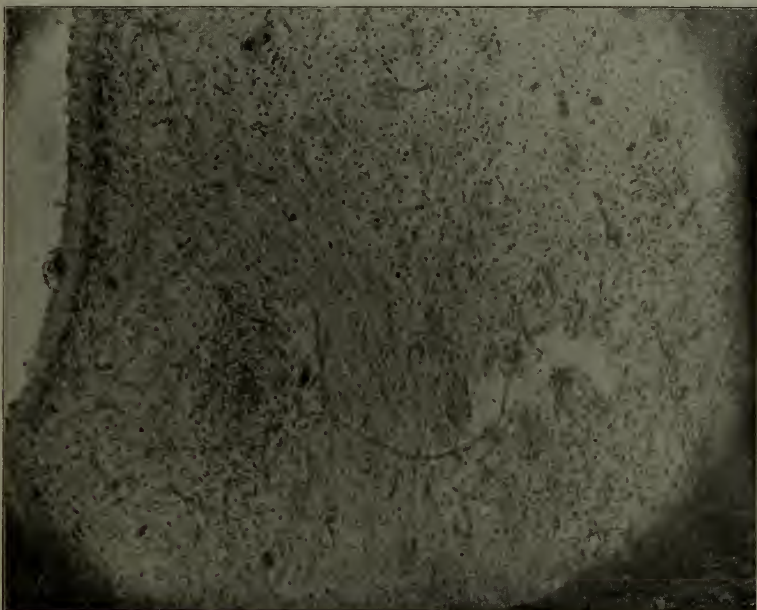


FIGURE 324
Microscopic section of dental pulp showing round celled infiltration (original). Eventually an abscess will form. X 67.

abscess, one of a series of multiplying abscesses which occur all through the specimen. The special nerve staining renders it a difficult matter to bring out all the cellular detail, but same can be well understood under the microscope.

Figure 324 is a cross section of pulp with very early localized round-cell infiltration just beneath the odontoblasts. The pulp shows a slight increase in connective-tissue cells all through it. Numerous nerve trunks are scattered here and there both in cross and oblique sections.

Figure 325 shows a further stage of Figure 324 with some cloudy swelling, coagulation and a slight central necrosis situated beneath and

to one side of the odontoblasts. Fibrous tissue with interstitial pulpitis is well seen further under the abscess, with considerable fatty degeneration at one end. Figure 326 is a very advanced sequela of inflammation occurring near the coronal portion of the pulp. Above the part photographed the tissue has fallen out from necrosis. There is a well marked necrotic area with considerable round-cell infiltration. Some cells take the hematoxylin stain very well, many of them, polynuclear leucocytes and others,

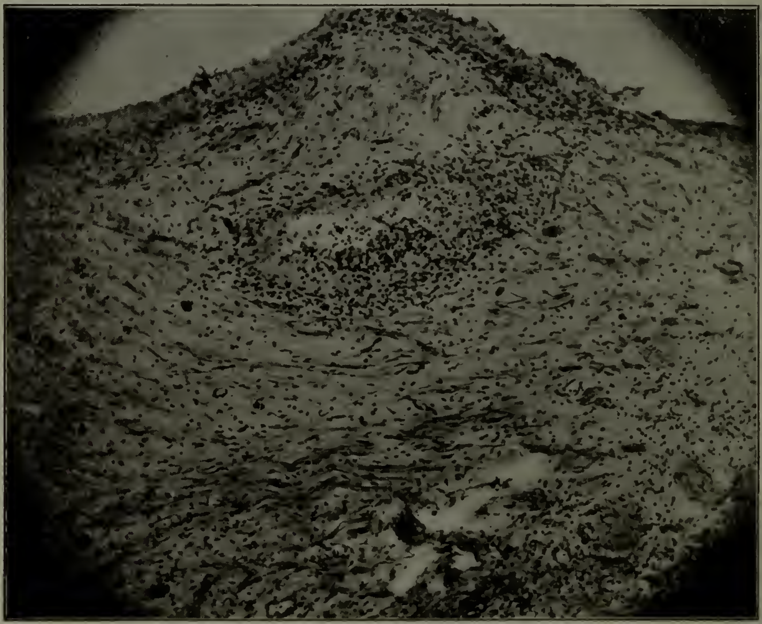


FIGURE 325
Microscopic section of dental pulp showing round celled infiltration further advanced (original). X 67.

hardly take it at all. Some attempts at fibroid tissue formation can also be seen, forming a trabeculæ for the cells in places. There are also a few very small pulp stones.

Figure 327 is even further advanced than Fig. 326. The whole of one horn is entirely inflamed and rapidly terminating in suppuration and necrosis. Many cells are in a state of parenchymatosis degeneration. Between strands of fibrous tissue, thickened and sclerosed nerve trunks, there are a very few small pulp stones around one end. On the further horn the odontoblasts are faintly outlined. In one spot there is a very small localized abscess, well marked round-cell infiltration; beneath, the pulp is nearly normal, only a slight increase in odontoblasts. Passing

down towards C, another abscess and a liquefying area appears, and to the outer odontoblastic zone a sclerosed nerve in a hyaline fibroid tissue; the odontoblasts are no longer to be seen, their nutriment basement layer has fallen away at the lower part; a few again appear towards the cervical pulp as normal odontoblasts, but under same and deeper in the tissue is some fatty degeneration with a fibroid root portion of the pulp.

Figure 328. The interest of this photomicrograph lies in the fact that the abscess is situated midway of the curved part between the bifurcation of the roots. The whole pulp is filled with a greatly increased cell

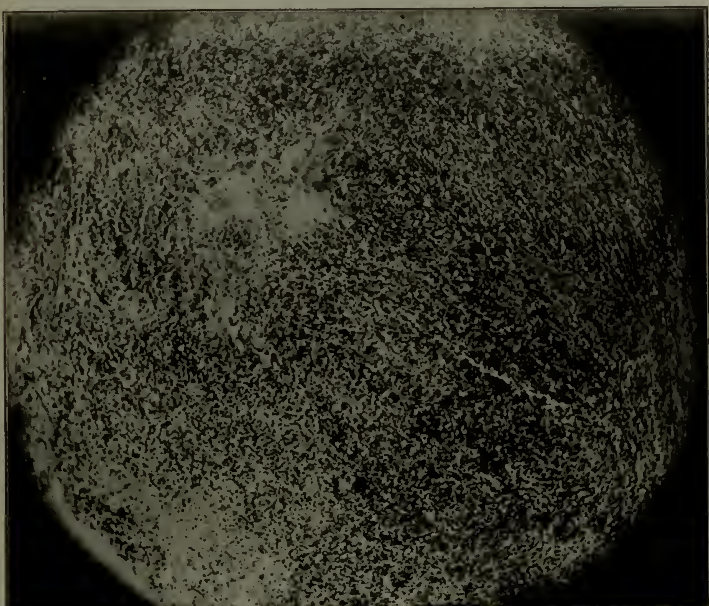


Figure 326
Microscopic section of dental pulp showing active inflammation and breaking down of tissue (original). X 131.

infiltration, especially in Weil's layer beneath the odontoblasts, the latter being granular in appearance. All the blood vessels are swollen and filled with a hyalin coagulation. A granular amorphous debris is seen everywhere through the basic substance of the pulp.

Figure 329 illustrates the extreme apical end of the pulp. One horn of the crown end is entirely destroyed by an abscess; the other horn is healthy. The nerve fibers are well stained. Passing down is a narrow area, slowly changing to a condition of atrophy. Below this the tissue

seems to be in a healthy condition. As we pass down toward the apex several small areas of round-cell infiltration may be seen, forming abscesses similar to Figure 322. The extreme apical end is shown in the picture, poorly-stained areas (cloudy swelling), some small fatty areas, trunks of degenerating nerve fibers,—a suppurative area among the fiber and blood vessels with necrosis at the tip of the pulp apex. An artery cut across with thickened walls may also be seen at the left of the picture.

I shall here call attention to this beautiful illustration, Figure 330. At A, diseased pulp in which is seen a circumscribed area of acute inflammation about to liquefy and form an abscess; C, a fully formed abscess, and B, the cicatricial tissue of an old abscess, showing conclusively that restora-

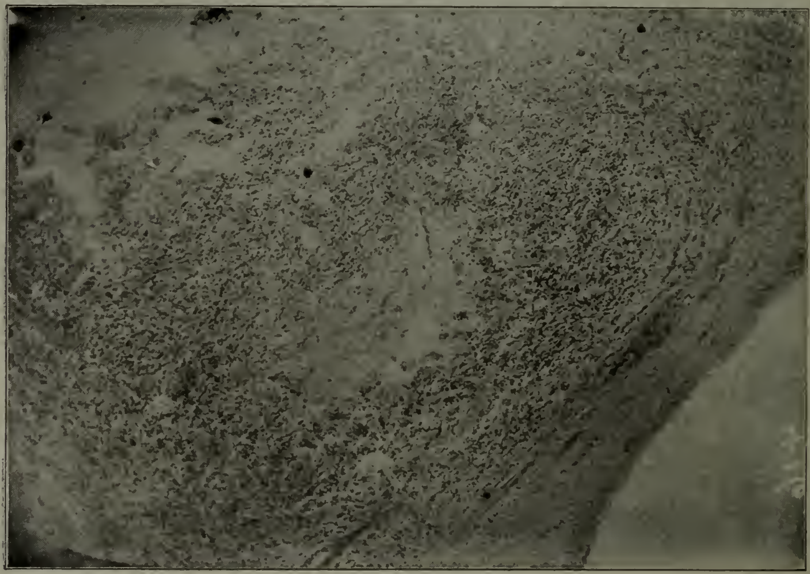


Figure 327
Microscopic section of dental pulp showing active inflammation and breaking down of tissue further advanced (original). X 29.

tion of a diseased pulp is possible. Speaking of want of lymphatics in the pulp Miller says, "It is for this reason that an abscess or center of inflammation the size of a pinhead in the pulp of a human tooth may cause excruciating pain, while its presence on the surface of the body might escape notice altogether." This, however, is not often the case. I have shown that in neurasthenia, hysteria, degeneracy and many diseases the peripheral nerves lose their sensation and hence little or no pain is experienced. Lymphatics are not connected with sensation except as to relief of pressure,

but nerve disorder readily interferes with transmission of pressure symptoms, necessary to constitute pain.

Nerve End Degeneration. For the purpose of studying this subject, teeth were collected, cracked open, and the pulps placed in different fluids for cutting, staining and mounting. Many methods and stains were used. Some of the stains that were successful on nerve tissue in other parts of the body were of little or no value on pulp tissue, for its

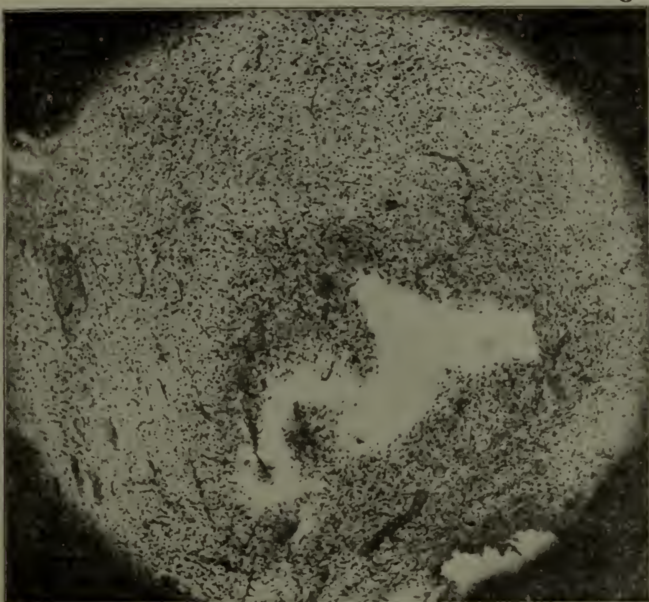


Figure 328
Microscopic section of dental pulp showing active inflammation and breaking down of tissue, formation of abscess (original). X 55.

unstable and degenerate nature makes the structure rarely twice alike. Care and attention are required to obtain good results.

Fig. 331 (partly schematic) shows Wallerian degeneration of nerve fibers after section. Thoma. 1, normal nerve fiber; 11 and 111, fibers in different degrees of degeneration; S, neurilemma; m, medullary sheath; A, axon; k, nucleus of neurilemma cell; L, marking of Lantermann; R, node of Ranvier; mt, drops of myelin; a, remains of axon; w, proliferating cells of neurilemma.

Fig. 332 shows one of the main nerves of the pulp, extending to the center where it branches into two distinct trunks. An artery faintly outlined may be seen behind the nerve trunk which also bifurcates like

the vessels being cut in such a way as to show the outer walls running parallel with the nerve trunk. The single vessels show the corpuscles plainly. The nerve trunk consists of the number of medullated nerve fibers. Internodes can be plainly seen in some of them. In some nerve fibers, variocosity or Wallerian degeneration is plainly seen. Internodes or Ranvier's nodes are also plainly seen. The basal structure of these illustrations is seen only partially or not at all, as they are stained specially to bring out nerve fibers.

Fig. 333. The nerve trunks show the medullated character very well, many nodes of Ranvier being in evidence. Varicosities and various

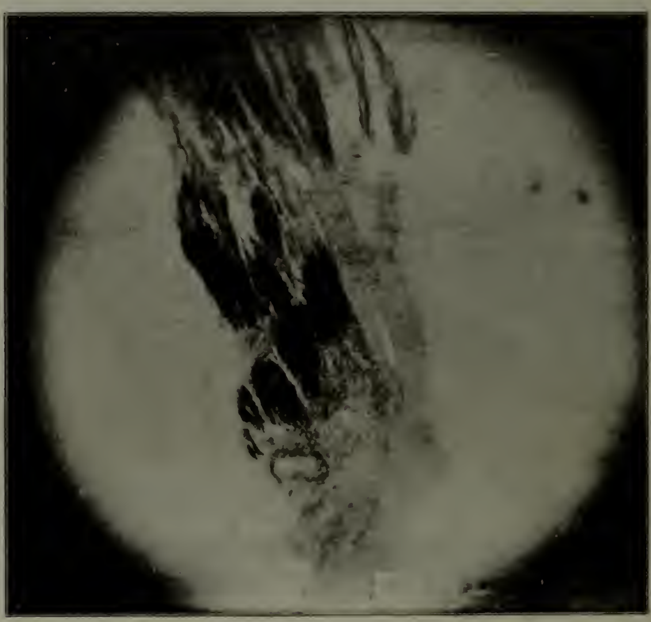


FIGURE 329
Microscopic section of dental pulp showing active inflammation and breaking down of tissue, formation of abscess at apical end of root (original). X 50.

degrees of degeneration can be followed in the individual fibers. In a few fibers, the darker axis cylinders with a higher stained primitive sheath are also seen. The various coats of the artery show the nuclei cut in transverse or vertical directions.

Fig. 334. The nerve fibers here present a much more swollen and thickened appearance than in Figs. 332 and 333. The nuclei of the fibers show clearly and also varying degrees of thickening. Some fibers show

the nerve. The vasomotor track is well marked by the circular coat of drops of myelin or Wallerian degeneration. The upper bundle of fibers has become thickened and sclerosed. The basal structure with connective tissue fibers and cells is better shown than in the other illustrations.

Fig. 335. In this illustration appears a large nerve trunk much increased in size and ending almost abruptly like a neuroma in an amputa-

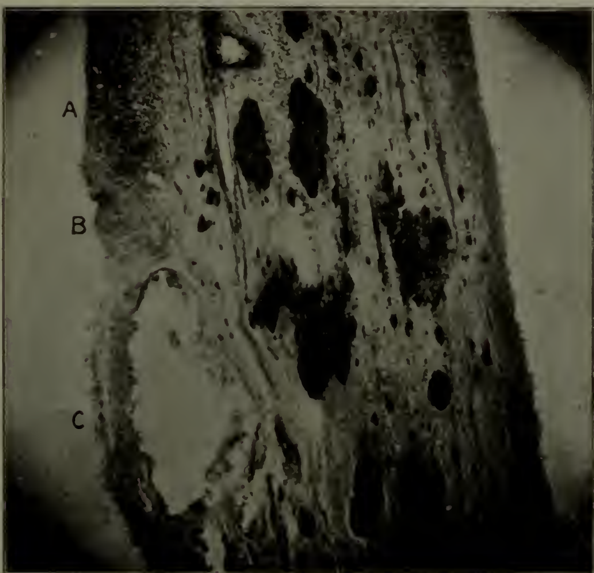


FIGURE 330
Microscopic section of dental pulp showing pulp stones and abscess in three different stages (original). *A*, shows active round cell inflammation; *C*, an abscess fully formed; *B*, cicatrical tissue of healed abscess. X 450.

tion. The basal structure is much altered, being of a chronic interstitial variety. There are few, if any connective tissue cells, but well marked bands of fibrous tissue. The individual nerve fibers show interruptions by the intermixing of the fibrous stroma, thus altering their function. The fibers are varicosed and vary in thickness.

I have demonstrated the vasomotor system and nerve endings in the arteries of the pulp, which together with nerve end degeneration and the blood are the three sources by which any and all diseases and poisons of the body may affect the pulp and thus lessen the resistance of tooth structure.

Thrombosis. Among vascular changes and circulatory disturbances, thrombosis in the blood vessels of the pulp is not uncommon. From the present knowledge of pathology and the pathogenic condition of the pulp, it is evident how thrombosis must occasionally result. The pulp, an end organ without anastomosis and collateral circulation, the blood returning through a single vein, creates an anatomic predisposition for formation

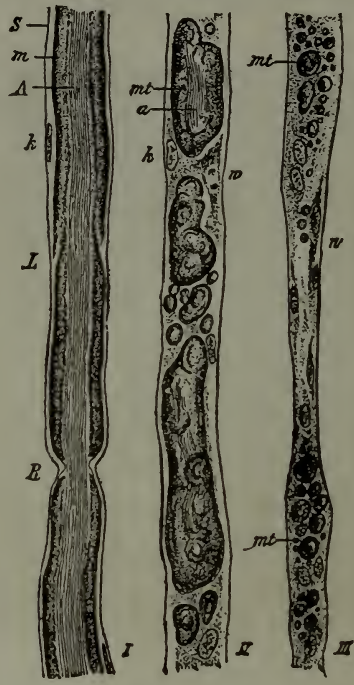


Figure 331
Diagrammatic illustration of a healthy nerve and nerve degeneration (Ziegler). This illustration is partly schematic and shows Wallerian degeneration of nerve fibers after section. Thoma. I, normal nerve fiber; II and III, fibers showing different degrees of degeneration; *S*, neurilemma; *m*, medullary sheath; *A*, axon; *k*, nucleus of neurilemma cell; *L*, marking of Lantermann; *R*, node of Ranvier; *mt*, drops of myelin; *a*, remains of axon; *w*, proliferating cells of neurilemma.

of a thrombus. The many degenerations and retrogressive changes which take place in the pulp make it susceptible to this morbid state. The spontaneous death of the pulp which sometimes follows disease can be thus accounted for. Formation of different calcic deposits causes the current to become slower and the leucocytes to be retarded in their progress from and to the apical end of the root canal. In time the blood plates separate from the blood current and are caught at the apical end of the

pulp canal. Sudden blindness occurs under similar conditions. The vessels become injured or abnormal, due to calcic deposits and other retrogressive changes and stasis take place, eventually furnishing a basis for future thrombosis and inflammation (Fig. 336).

A thrombus may be located in any part of the arterial system, but more especially the heart. Simple or septic fragments may become dislodged and carried through the blood streams to or into the pulp of the tooth. Having entered this cavity, its return is almost impossible.

Embolism consists of various structures, such as fat drops, tissue fragments, tumor cells, air, etc. These follow the blood current. The

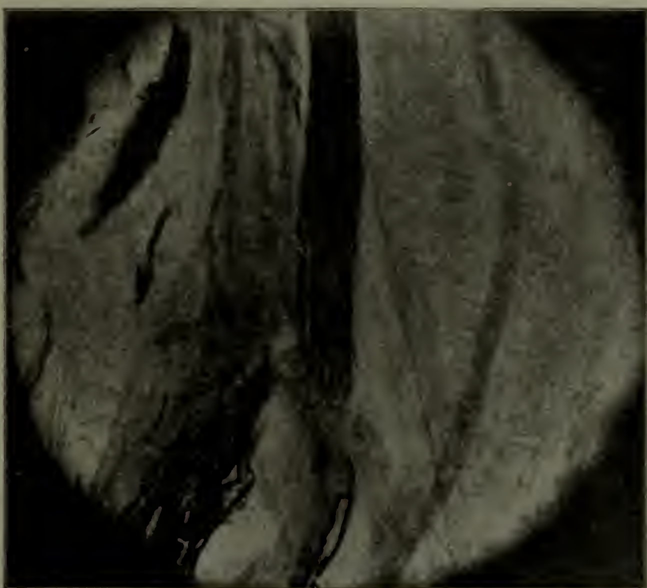


Figure 332
Microscopic section of dental pulp showing nerve end degeneration (original). X 143.

size of the body regulates the distance to which an embolus may travel. It stops in vessels whose lumen prevents its passage. More frequently it is arrested at the bifurcation of the artery. The pulp is especially adapted for this purpose, since it is an end organ, with numerous loops terminating in one or more veins for exit.

Emboli, according to Hektoen, act in two ways, mechanically, clogging the circulation, and specific, depending on the nature of the embilus, whether infected or sterile, whether composed of dead or living cells, capable of further proliferation. The circulation may be mechanically

obstructed. If septic material has lodged in a blood vessel, inflammation may extend to the surrounding tissues (Fig. 337).

ENDARTERITIS OBLITERANS AND ARTERIO-SCLEROSIS. Inflammation of the arterial coats in the pulp is very common. This is due, in a degree, to pulp embryogeny, anatomy, environment and to its end-organ nature, as already stated. The diseases most commonly observed are endarteritis obliterans, arterio-sclerosis. While it is not uncommon for each coat of the artery to take on a special type of inflammation, yet all frequently become involved.

Endarteritis obliterans is an inflammation of the inner coat of the artery, usually of a chronic type. The inflammation may arise from an

FIGURE 333
Microscopic section of dental pulp showing nerve end degeneration (original). X 162.

irritant in the blood current from the main current, through the vaso vasorum or through the lymphatics. The first is the most usual; in the alveolar process all three may occur. In the pulp, irritation in the blood stream is the most common method. Proliferation of the endothelium results. Bands of fibrous tissue develop. The blood vessels become obstructed and finally obliterated, impeding the circulation (Fig. 338).

The structure pulp, made up of loops of blood vessels and situated within bony walls, with only one or two arteries and veins for the passage

of blood, renders it a unique end organ, and its arteries susceptible to arterio-sclerosis. This, together with endarteritis obliterans, predispose the arteries to degeneration and necrosis. This is a thickening of the arterial walls, especially of the intima. It is secondary, according to Hektoen, to certain inflammatory or degenerative changes in the media. This is seldom observed early in life. It is commonly found after puberty, but more frequently at the senile stage, from forty years on. The causes producing arterio-sclerosis in other parts of the body produce it in the pulp arteries.

The causes are usually autointoxication and drugs taken into the system, which likewise become irritants. Beside the distensive force and

FIGURE 334
Microscopic section showing three bundles of nerve fibers with Wallerian degeneration and foci of inflammation (original). X 156.

change in composition of the blood, local irritation on the arterial wall is an active cause. In disease such as syphilis, gout, rheumatism, Bright's disease, alcoholism and chronic mercurial, lead, brass, arsenic and bromide poisoning the walls become irritated, resulting in thickening of the arterial coats.

"The inebriate, whose brain and body after death exhibit a confused mass of wreckage, which the pathologist is often unable to trace back to the exact causes and conditions, has, according to Crothers, always sclerotic

conditions of the large and small arteries, together with atrophic and hyperatrophic states of the heart, kidneys and liver, with fatty degeneration and calcification of the coats of the arteries. These organic changes are so frequently present in inebriates that they constitute a marked pathology which is traceable to the use of alcohol."

These irritants, acting through the vasomotor system and increasing the arterial pressure, finally cause paralysis and diminution of the caliber

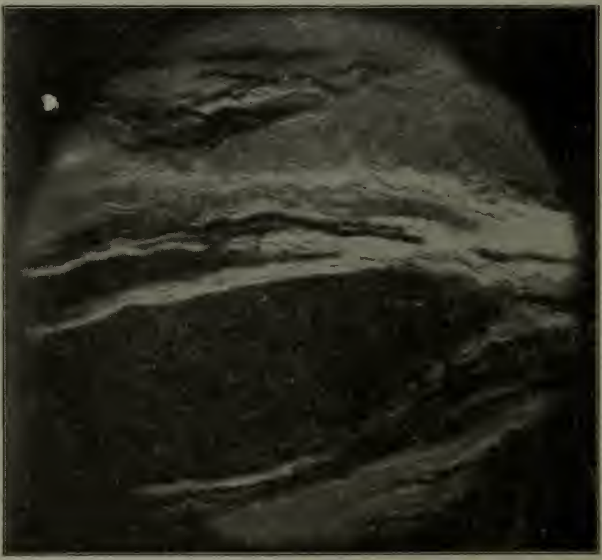


Figure 335
Microscopic section of the dental pulp showing nerves in the arterial coats of arteries and also a large nerve trunk showing Wallerian degeneration (original). X 143.

of the arteries and capillaries, producing stasis of blood (Fig. 339). This morbid state of the arteries tends to produce any or all of the other degenerations previously referred to.

The inflammatory process of the intima was first charged to direct irritation of material floating in the blood. Rokitansky and Thoma are of opinion that it is secondary and dependent on the degenerative changes of the middle coat. This view I can not accept, since autointoxic states produce irritation in the blood streams.

Many degenerations of the pulp are the result of arterio-sclerosis, endarteritis obliterans and nerve degeneration. These degenerations occur in connection with each other; in other words, sometimes two, three and even more are to be found in the same pulp. The causes producing these degenerations are not understood.

Retrogressive Changes. One direct result of arterio-sclerosis and endarteritis obliterans is cloudy swelling and fatty degeneration. These conditions are observed in connection with such diseases as typhoid fever, septicemia and other acute infections and toxic diseases. The tissues present a whitish or shiny appearance, without fibrous structures. Under the microscope the tissues present an opaque mass and do not take stain. The cells are quite large and swollen (Fig. 340).

"When a tissue, as for instance the heart muscle, receives a diminished quantity of blood on account of the narrowing of the lumen of the arteries due to thrombosis, embolism or disease accompanied by thickening of the

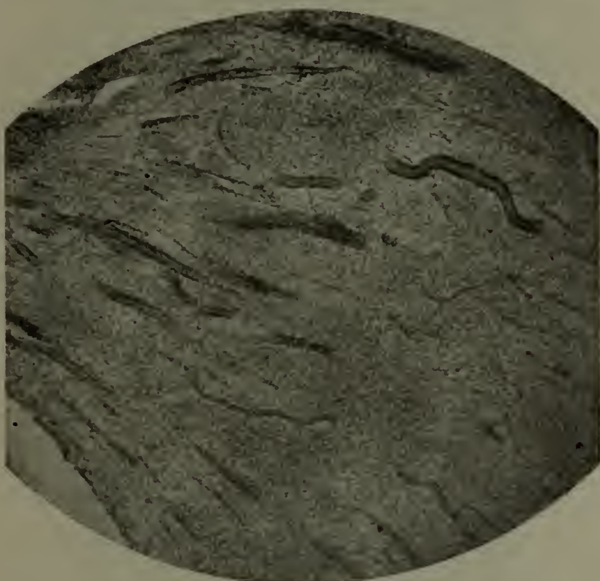


Figure 336

Microscopic section of dental pulp showing thrombosis of the capillaries and inflammation (original). Arteries and capillaries are closed. The acute inflammation shows there has been an hyperemic condition. X 137.

intima, albuminous and fatty changing, remarks Hektoen, usually result. In the case of the different forms of anemias, degenerations with fat production are found in the liver, heart, kidneys and muscles. In such conditions there is not enough oxygen and other nutritive material to maintain the function of the cells. In actual starvation there is first absorption of all the fat in the body, accompanied by a marked diminution of the structure. In the later stages, albumin and fatty degeneration take place. Albuminal and fatty changes are very common in febrile diseases. They occur in practically infectious diseases and in a large number of the intoxi-

cations, such as the drug poisons. They are also found in abnormal metabolism, due to direct action of poisons and the abnormal process of oxidation." Owing to the pulp's peculiar structure and environment, fatty degeneration is commonly found in its tissue (Fig. 341).

Amyloid degeneration is a peculiar degeneration of the connective tissue, causing an albuminous substance to be deposited in the surrounding tissue. The walls of the blood vessels also become involved. It presents a shiny appearance and differs from other tissues in that it turns a dark

Figure 337
Microscopic section of dental pulp showing dilated vessel, diapedesis and embolus. X 280.

red color with iodin. The morbid state is found in syphilis, tuberculosis, chronic dysentry, etc. (Fig. 342).

Almost every structure in the body may be involved.

Hyaline degeneration (Fig. 343) is, according to Stengle, closely allied with amyloid, mucoid and colloid degeneration, and all can pass into each other. It can occur in tissues during infectious and septic processes, following traumatism, in autointoxications such as drug poison,

hemorrhages in cicatrices, in senile blood vessels, arterio-sclerosis, endarteritis obliterans and in the nervous system. It can also occur in connective tissue which has undergone a change by inflammation. This morbid state depends for its action on local or general nutritive disturbances. The pulp, therefore, is susceptible to it. The intima, as well as the entire walls of the small blood vessels in the pulp, easily becomes involved. Some investigators believe that fat connective tissue cells so arrange

FIGURE 338
Microscopic section of dental pulp showing endarteritis obliterans (original). The wall in one artery is thickened (endarteritis) and almost occluded by inflammatory products. In the smaller artery the intima contains round-celled infiltration, almost occluding it. The pulp tissues show the myxomatous character very well, branched spindle and round nucleated cells in many places. X 225.

themselves as to undergo a change into myaline substances (Fig. 344). These ultimately lead to calcification.

CALCIC DEPOSITS. This raises the question of calcic deposits or so-called pulp stones. Pathologists know that tissues elsewhere in the body (which have necrosed or degenerated) are the localities where lime salts are deposited. Dying tissue which has undergone more or less change possesses, according to Ziegler, a kind of attraction for the lime salts in solution in the body. The tissues, to which attention has been called, are especially susceptible to calcic changes; hyaline and fatty degen-

eration, tissues involved in disease or drug poisoning, already mentioned here and elsewhere. Regions affected by slight degeneration and in structures like the pulp, a constricted end organ, are predisposed to deposits of lime salts. Calcic deposits have different shapes and location in the pulp tissue. Circumscribed structures appearing solid under the miscroscope, to the naked eye or to the touch, are not pulp stones or calcic deposits, but in a large percentage of cases belong to other retrogressive changes. These deposits (Fig. 345) are, no doubt, due to degeneration of pulp tissue, especially in structures undergoing hyaline or fatty degeneration. Large

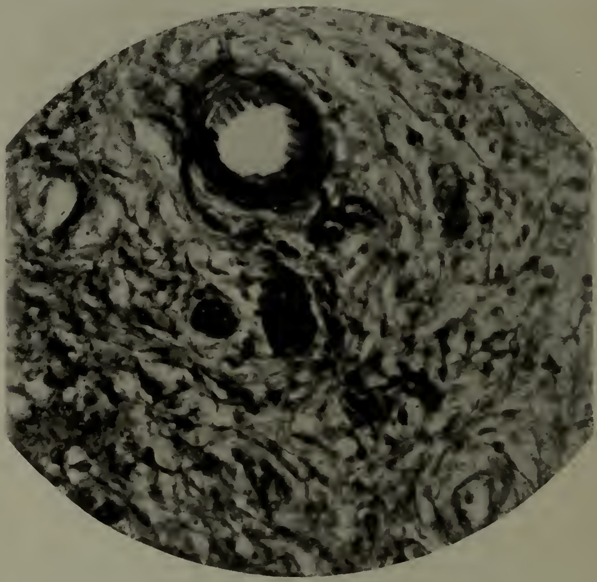


Figure 339
Microscopic section of dental pulp showing enlarged artery in early stages of thickening (original). The small vessels are plugged up; there is well marked myxomatous pulp tissue. X 225.

masses of deposits in the form of spherules often occur. Bone formations are sometimes observed. These deposits, both in pulp stones and spherules, take on a dirty, bluish-violet color, with hematoxylin. These Dr. Latham and I have observed many times. Crystals may sometimes occur.

"This applies, however, as Ziegler remarks, only to deposits of lime carbonates and phosphates and not to those of lime oxalate." These deposits may take place at any time, but are most likely at the senile or fourth period of stress.

Fibroid Degenerative growth of the pulp may be both rapid or slow. Inflammatory reaction in fibrous pulps is rare, although when

followed by infection or exposure, it may take place. Various degeneracies like those already mentioned are liable to occur, especially those in which connective tissue in general is predisposed. The fibers are observed in bundles, closely packed together, with many connective tissue corpuscles shown at intervals. Fibroid degeneration is easily distinguished from the other degeneracies of the pulp (Fig. 346).

In these cases, the blood vessels and nerve tissue are relatively few. The blood vessels remaining usually have thickened walls, especially in

FIGURE 340

Microscopic section of dental pulp showing pulp stones (original). The pulp stones are scattered throughout; here and there a form of round celled infiltration, longitudinal trunks, few degenerated vessels surrounded by hyaline degeneration in the middle of nerve trunk; early sclerosis and cloudy swelling or granular degeneration; adontoblasts in situ. X 21.

the external and middle coats. This, of course, narrows the lumen. Not infrequently the blood vessels are entirely obliterated. These fibromas, very common in exposed pulps, are not now under consideration. In nearly if not all of these degenerations the blood vessels are first involved, later nerve tissue.

All these degenerations, including the pathologic processes of evolution, are the direct constitutional causes of tooth decay, erosion and abrasion brought about by diminution of tooth vitality.

Summary

The pulp is developed from the dental papilla derived from the mucosa beneath the basement membrane, which differs from the enamel organ in possessing arteries, veins, and nerves.

In the teeth of the lower animals the pulp is as large as the base of the tooth, furnishing complete nourishment, but as the species ascend, the

FIGURE 341

Microscopic section of dental pulp showing fatty degeneration (original). In this illustration are also seen beside fatty degeneration, acute pulpitis, sclerosis of nerves, nerve degeneration, dilation of vessels, faint outline of degenerated adontoblasts. X 137.

pulp contracts at the neck until in the human teeth they are nearly closed, making of the tooth a foreign body and the pulp itself a characteristic end-organ.

Under unstable nervous system or other defects various abnormalities occur in the dentine development, either phylogenetic or ontogenetic in nature, producing teeth that are prone to decay.

The question of lymphatics in pulp is as yet unsettled, but experiments demonstrate that a drainage does exist, and that pulps do repair themselves after decay and abscesses.

The teeth are furnished with a very complete system of vasomotor nerves, entering and emerging through the apical foramina, the number depending upon the size of the foraminal opening. As man advances in age and exostosis, the opening naturally grows smaller.

The causes which bring about diseases of the pulp consist of changes in the blood current, due to circulating poisons, resulting from degenerative conditions occurring at periods of stress.

Pathologic degeneration of the pulp begins when it has ceased to form dentine and the apical end is nearly closed, rendering it a typical end-organ

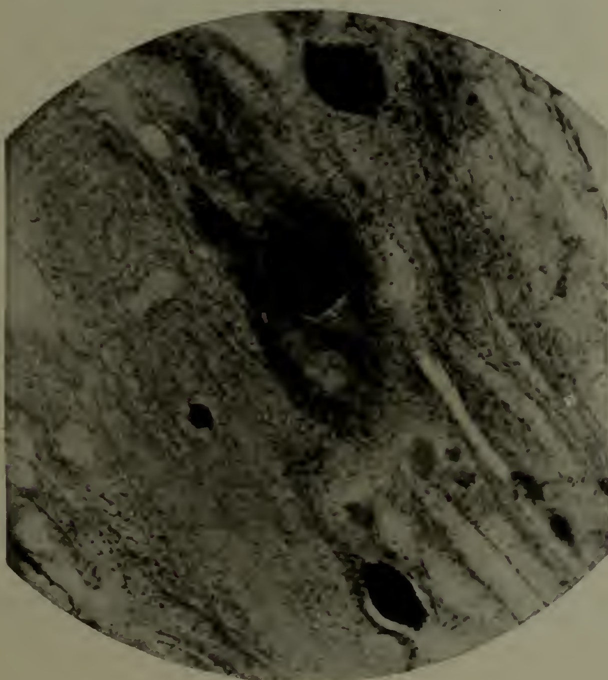


FIGURE 342
Microscopic section of dental pulp (original). Shows pulp stones and their close relation to the vascular channels. Dilated vessels with amyloid deposit. X 62.

enclosed within bony unyielding walls, where it cannot expand and where the high blood pressure of toxic conditions easily ruptures the vessels. No other part of the body is so susceptible to local hyperemia and pressure necrosis. And on the other hand, no part is so liable to constriction anaemia, with its constricted neck and its terminal arteries having no anastomosis.

All these conditions of the pulp are readily produced or accentuated by the action of the vasomotor system upon its terminal arteries.

Inflammatory processes in the pulp may pass through all the stages, from infection to abscess, without pain.

Thrombosis is not uncommon in the pulp, formed by the lodgement of simple or infective matter in the vessels, due to the friction of calcic deposits, and accounts for frequent apparently spontaneous death of the pulp. The lack of anastomosis and collateral circulation, and the return of the blood through a single vein, renders the pulp specially favorable to thrombosis.

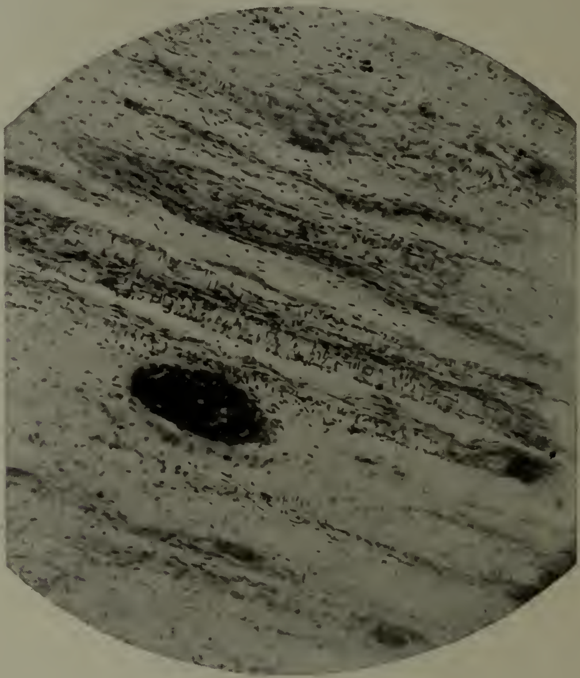


FIGURE 343
Microscopic section of dental pulp (original). Shows calcareous deposit, medullary nerve, early connective tissue formation. X 225.

Embolism not infrequently occurs in the pulp from the same causes to which, being an end-organ with numerous vascular loops, it is peculiarly liable.

The same end-organ conditions make the pulp a frequent seat of endarteritis obliterans, due to irritants in the blood stream or the lymphatics. Degeneration and necrosis of the pulp of course ensue. The underlying causes are autointoxication resulting from diseases such as syphilis

gout, rheumatism, Bright's disease, alcoholism and poisoning by various metals and drugs.

Cloudy swelling, amyloid, hyaline and fatty degeneration, such as occur in the kidneys, take place equally and under the same conditions in the tooth pulp.

Just as necrosed or degenerated tissues elsewhere in the body are the seat of calcic deposits, so the pulp under similar conditions becomes the

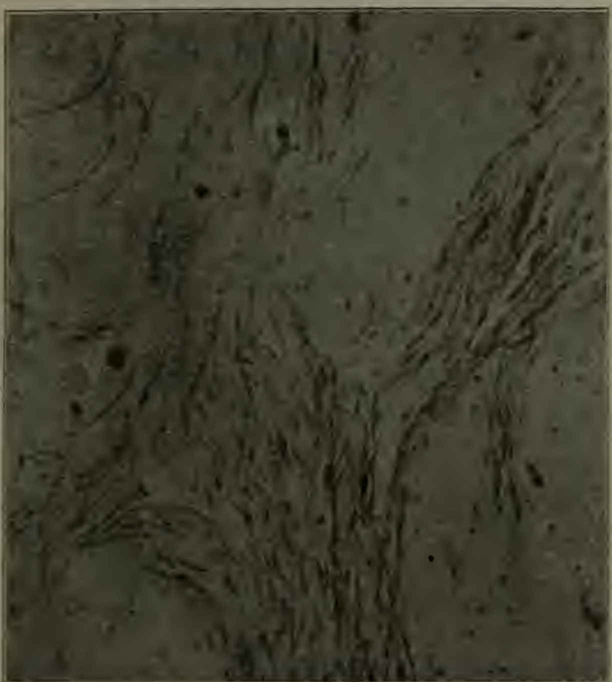


FIGURE 344
Microscopic section of dental pulp (original). Shows medullary nerve fibers, internodes, axis cylinders, myalin degeneration. X 280.

seat of so-called pulp stones, which are most likely to occur at the fourth or senile period of stress, because lime salts are then in process of absorption.

All these forms of degeneration, together with the pathologic processes of evolution, are the direct causes of tooth decay.

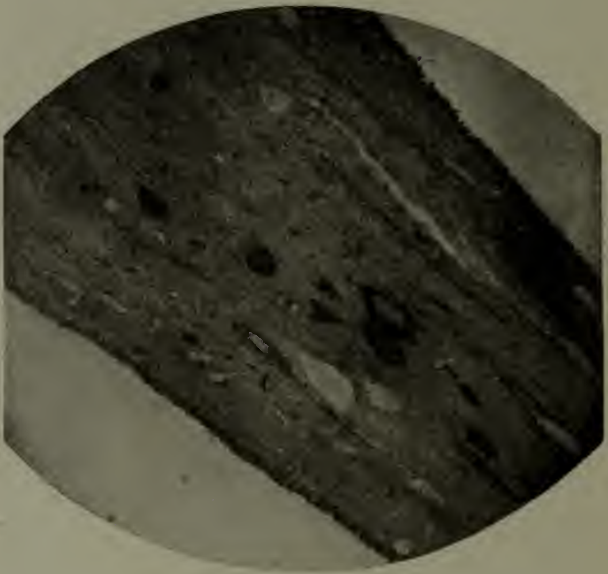


FIGURE 345

Microscopic section of dental pulp (original). Shows medullary nerve fibers slightly thickened. The connective tissue is degenerating and hyaline adontoblasts show well on both surfaces. X 156.

FIGURE 346
Microscopic section of dental pulp (original). Shows interstitial fibrosis with acute inflammatory cells. Odontoblasts have been destroyed. X 22.

Chapter XXIX

THE EFFECTS OF PULP DISEASE ON TOOTH STRUCTURE

DISEASES of the tooth pulp produce disastrous results on tooth structure. These resultant conditions consist in soft teeth, erosion, abrasion, discoloration, and a want of tooth resistance to the ravages of decay.

In Chapter XXV, "The Vertebrate Teeth," it was shown that the teeth, in their ontogeny, at the first period of stress, passed through their phylogeny; that arrests in phylogeny occur as in other structures of the body. The jaws and teeth occasionally become arrested in their phylogeny, at the higher mammal stage (lower savage), and develop large. The teeth are then hard, dense and perfectly formed. These may be considered hard teeth; they rarely decay or become soft and abrasion and erosion are rarely seen except in the most severe forms of disease.

After the pulp has finished its work of forming dentine, it still has a slight physiologic function, in that it gives life to the dentine through the dental pulp and fibrillae. These fibrillae extend through the dentine to the periphery.

Andrews states that "when the tooth is fully formed, the principal function of the pulp is for vitalization of the substance of the dentine, by means of its fibrils, which permeate into every portion of the matrix of the dentine. Its function is not only to vitalize, but it may again assume its formative function whenever causes for repair demand this. . . . We cannot look on its tissue in life, . . . conclusions must be drawn from what is shown to have taken place when the tissue was alive; the living pulp, with its blood vessels and nerves, nourishes the dentine; vital changes do take place, and the pulp is the source of vital action. It is a living organ, subject to any physiologic or pathologic process which may act on any living matter; its connection with the general economy must be similar to that of other tissues. It will respond to the action of returning health and caries which has commenced has been arrested by this vital action, appearing as polished blotches on the teeth, which are not uncommon.

Miller, in his work on Micro-Organisms of the Human Mouth, calls this condition a spontaneous healing of dental decay. The dentine, which had become softened, has become hard again, and the decaying process is stopped. This change also takes place in the temporary teeth. The healed dentine retains its discolored appearance, but becomes nearly as dense as normal dentine. These changes have been brought about by vital action and this action came from the agency of the pulp.

When the dentine is irritated by infection or its surface is uncovered by a break, there immediately follows a period of vital activity. If sections of a tooth made when these changes are taking place be examined, the formative cells in that portion of the pulp nearest the point of repair are found filling up with glistening globular bodies and the tissue about it is showing an increased vascularity, as though active formative action were taking place."

Andrews was satisfied that these appearances were the result of the vital action of the pulp in its efforts to repair the tissue and that the minute glistening particles within the canals were in many ways similar to the minute globular bodies found in the tissues while the dentine matrix was developing.

"The protecting consolidation is found in teeth that are worn down, usually in the mouths of old people, and when this change has taken place these teeth are not liable to decay again, except under very favorable circumstances . . . . These changes are due in a large measure to normal conditions as regards the vitality of the individual; but in cases where the constitutional condition is below the normal, even where conditions seem favorable to decay, there is always an attempt made to retard the infection. Under certain conditions of environment and infection, penetrating decay is so rapid that the vital action of the pulp is overwhelmed, and the pulp becomes exposed and is in a pathologic condition even before the breaking away of the cavity walls.

"The pulp is the central and largest source of vitality to the tooth, and it acts through its myriads of fibrils . . . . Pain of the dentine following the touch of an instrument or from any irritation is expressed through the agency of these fibrils, and we become conscious of the sensation through them . . . . . The dentine is and was meant at all times to be a living tissue. It receives impressions of injuries and responds by processes of repair. Some of the ablest men in the profession have questioned the further value of the tooth-pulp after the full formation of the tooth has taken place. They look on it simply as a formative organ and consider its mission closed with the formation of the tooth. It is, therefore, in their judgment quite as well to destroy it, take it out and fill its chamber. The microscopic appearance of dentine after the pulp is removed shows that a large amount of dead organic tissue is left within the canals that cannot be taken out, and the dead tissue is a source of considerable danger to the health and vitality of the pericementum . . . . With death of pulp, not only is sensation in the dentine lost but also all the changes which vitality gives to an organ, such as nutrition and recuperation."

It is a well known fact that as man grows older, although in apparently

normal health, his teeth discolor; erosion and abrasion also occur, and in some patients, instead of the teeth remaining hard and without decay, decay is rapidly causing the teeth to disintegrate.

As a general thing, patients go to the office of the dental specialist only when purely dental treatment is required. Rarely is he called when the patient is ill at home. The dental specialist, therefore, is not made aware that bodily disease is undermining the system of his patients, because when he sees them, they appear strong, from a physical standpoint, whereas they are really sensitive and defective in vitality. A patient may have faulty metabolism and autointoxication and yet live to a good old age, but the teeth will under these conditions, discolor and disintegrate early in life. These systemic conditions, indeed, first manifest themselves in the mouth, jaws and teeth.

The changes, then, which bring about loss of sensation and vitality, causing a want of proper nutrition and recuperation, are faulty metabolism, autointoxication and neurasthenia, which in them produce poisons circulating in the blood, impoverished blood, and nerve end degeneration.

First to be considered of these conditions are the metabolic toxemias and the autointoxications. Metabolic toxemias are those bodily poisons which arise from the body proper in the blood, tissue, and organs. Autointoxications are those poisons which arise from the gastro-intestinal tract, which are within the body and yet are not of the body.

Metabolic Toxemias. The cells of the body are the unit of bodily activity. In health, they repair, increase, and propagate themselves. When the eliminatory organs, the skin, lungs, bowels, or kidneys fail to perform their functions normally every cell is subjected to toxic influence. These body cells then become poisoned, and toxic conditions of the blood result. Disease, in children or adults, will also produce bodily poisons.

Autointoxication. The dietetic question is one of vital importance to each individual; while in the growing child plenty of good nourishing food is essential to the welfare of the body, yet when the body has attained its full growth a lessened amount of food will keep the body well nourished. When more food is taken into the system than can be digested and assimilated, "high livers" as they are called, become overfed, the waste products are retained in the alimentary canal, and the toxins, by fermentation and putrefaction produce bad results upon the individual. So intensified may these toxins become, that death not infrequently results. Poisons due to autointoxication are best observed in an examination of the urine, the two most important symptoms being indicanuria and excessive urinary acidity.

Toxins from both faulty metabolism and autointoxication, if not properly eliminated, will produce changes in the blood stream, resulting in disease of some one or all of the tissues of the body. Owing to location,

shape, or peculiar anatomy, some structures are more quickly involved in disease than others.

Such structures are the transitory and end organs. The dental pulp, as has been shown, is the most perfect specimen of this type of organ in the human body. The trouble may be so widespread as to involve the pulp as a whole, thus causing the entire tooth to become involved, or only certain areas of the pulp are affected, in which case only certain parts of the crown become discolored or softened. The poisons, circulating in the blood, cause all the diseases enumerated in Chapter XXVIII, "The Dental Pulp." The dental fibrillae are destroyed, and nourishment of that part of the tooth is cut off. Tooth resistance is thus destroyed. Discoloration and tooth softening now take place. Friction, from any substance, readily wears the soft portions of the tooth away, causing erosion and abrasion, both being arrest in phylogeny as far back as the adult reptilian hatteria. Tooth decay results from external causes from want of tooth resistance. We must not lose sight of the fact that the teeth of children with an unstable nervous system are not well developed in structure because the line salts have been diverted to other tissues (the brain and skull) under the law of economy of growth. This fact is well illustrated in those teeth (especially molars) which tend to conate (Figs. 269, 274 and 281) and in which owing to very imperfect structure decay takes place rapidly.

Neurasthenia is a common neurosis by which, Preston remarks, males are equally affected with females. It is a nerve instability to which in addition to ordinary nerve fatigue there is a morbid susceptibility to emotions and inability to restrain their manifestations. It is apt to make its onset near puberty when permanent teeth are most liable to decay. Temporary teeth are frequently badly discolored, softened and decayed as a result of child neuropathy, hysteria, and disease. Permanent teeth later in life decay from premature senile neuropathy. Neurotic inheritance aided by the influence of climate and race tendencies, and anunstable, badly organized or imperfectly developed nervous system, are potent factors in tooth decay. When to this are added diatheses like tuberculosis, syphilis, etc., causes for tooth softening, discoloration and decay are enormously increased. Any long-continued disease, grief, worry, starvation, fear of litigation or death, also cause faulty metabolism, autointoxication and excessive nerve fatigue, an excessive nerve waste and its retention. Anxiety, especially of young children, and between the ages of twelve and twenty-four, relative to their standing in school, is a fruitful source of nerve tire, nerve waste, and faulty metabolism. The forcing system of schools adds neurasthenia to the lists of accomplishments. While "all work and no play makes Jack a dull boy" from nerve tire and self-poisoning, the same is even more true of Jack's sister. Few universities do not

have in their faculties fairly typic neurasthenics from pedagogic worry and too one-sided life.

The causes just enumerated are in adults fruitful sources of nerve exhaustion. Elsewhere I have frequently shown that any excess is a fecund cause of nerve exhaustion. Neurasthenia occurs in every walk of life. People raised in luxury and idleness are the most evident victims of neurasthenia. The lowest classes, who give free rein to the appetites, and the tramps are often neurasthenics, as are those between these two, persons who lead a sedentary life to which is added severe mental strain, care, responsibility, monotony, anxiety. Neurasthenia is frequent among clerks, teachers, literary workers, etc. It is often the ancestral phase of degeneracy; through it occurs the rapid decay of the teeth in persons over thirty or forty years of age who have had very little decay previously.

The local causes are thereby accelerated. In all the cases enumerated, either the nervous system or blood supply or both are involved. While all of these lesions are observed early in life, they are most active after forty years of age. It is especially at the senile stage—the fifth period of stress, or period of involution, when the excretory organs, from overwork or nerve tire, cause faulty metabolism and autointoxication—that the teeth undergo changes indicated by rapid decay, discoloration, erosion and abrasion.

Changes taking place in tooth-structure must necessarily occur either in the blood stream or nerve tissue. Investigations of nerve lesions have demonstrated that in most diseases, nerve-end degeneration takes place, as Sidney Kuh has shown. In some of the toxic forms, as, for instance, in neuritis due to poisoning with lead and arsenic, the cells of the spinal cord as well as those of the spinal ganglia and brain may be diseased and the toxic substances may attack these cells before the nerve fiber itself is altered. This hypothesis explains why pronounced degeneration of peripheral nerves occurs without causing any appreciable symptoms. Pitres and Vaillard first showed that after typhoid fever many nerve fibers are found degenerated in cases where, during life, symptoms of neuritis were absent. The same observer found like states in the nerves of those who had died from tuberculosis. Later observations have extended these conditions to such diseases as diphtheria, syphilis, alcoholism, carcinoma, inanition, marasmus, arterio-sclerosis, and leprosy; in the so-called rheumatic neuritis of the facial nerve, and in inflammation due to articular rheumatism, gout, puerperal infection, tuberculosis, etc.

The method of cell-poisoning has been observed in other intoxications. Certain groups of neurons are more susceptible than others to a given intoxication. The same group of nerve cells in two individuals may react very differently to similar doses of the poison. The syphilitic toxin shows

a decided preference for certain parts of the cerebral cortex, other areas being less affected. The nerve endings in all parts of the body are markedly involved, especially those in and about the teeth. Peripheral nerve degeneration results where the blood current or the nerves themselves are involved from faulty metabolism, neurasthenia, etc.

If disease affects nerve endings elsewhere in the body, it is but reasonable to believe that nerve endings, blood vessels and connective tissue in the pulp will likewise be involved, since the pulp is an end organ situated within bony walls, and a transitory structure is doubly susceptible to disease. The tooth pulp as has been shown is at its highest physical development when it commences to form dentine. From that time it degenerates; it begins to lose its blood supply and its nerve energy. As age advances, the blood and nerve supply is almost at a minimum. Is it surprising that so few pulps are found in normal condition?

Dr. Vida A. Latham and myself have made a special study of dental pulp pathology. The results of our efforts have been presented before the Section on Stomatology of the American Medical Association and published in the Journal of that organization.

A few illustrations will not be out of place at this time.

In any public institution for degenerate children the teeth will be found badly decayed. Teeth of degenerate children living at home decay faster than those of healthy children of the same family. Teeth of pregnant women decay faster than before pregnancy. At the senile period or the period of involution under mental strain teeth decay rapidly.

A forty-six-year-old woman had two sons and a daughter. The daughter at eighteen was attacked by peritonitis and died within a week. From persistent grief of the mother the teeth, previously in good condition, presented in eight months many cavities. Erosion, abrasion and discoloration followed.

A forty-two-year-old woman was well-to-do financially. Her husband had charge of her property. She went abroad for two years and he was to bring her home at the end of that period. He failed to do so and kept her abroad for two years more. Remittances becoming short, she returned to find that her husband had squandered all her property, so she obtained a divorce. Resultant worry, as dermatologists would believe, turned her hair white. There was likewise marked recession of the alveolar process and gums from interstitial gingivitis as well as rapid decay of the teeth.

The teeth of a thirty-five-year-old woman became soft and decayed rapidly from deep grief over the sudden death of her husband.

Grief from its trophic results causes abrasion and erosion. The most marked cases are those occurring from death of husband, wife or children or loss of wealth. Drilling into pulp cavities of these types is often done

without pain or hemorrhage; pulps are removed without pain and with little hemorrhage; marked changes take place in enamel and dentine; the tissues not infrequently become softened; the incisors break off near the gum under pressure. All of these states occur in neurasthenia and melancholia.

A forty-eight-year-old newspaper owner and editor became postmaster of a large city. Resultant mental strain produced neurasthenia, with interstitial gingivitis and rapid decay of the teeth. Here the teeth were normally hard as flint, the enamel cut with difficulty, the dentine was as hard as the enamel. When the extra nerve strain was applied the enamel became brittle and the dentine cut like horn or old cheese.

Tooth decay occurs much more rapidly when neurasthenia is present, irrespective of the cause.

The teeth of paretic dements and tabetics decay rapidly. People who possess neurotic tendencies and inherited taint from consanguineous marriages or excesses suffer from tooth decay and irregularities. Severe illness will cause tooth decay and change the color to a dirty yellow, regardless of age, softening tooth structure. In hemiatrophy tooth decay and interstitial gingivitis occur on the affected side and perhaps to a lesser extent on the other. In heart lesions (fatty degeneration, valvular disease, etc.) decay is rapid. Syphilitic and tubercular patients have tooth decay and interstitial gingivitis, while tooth erosion, abrasion and discoloration also occur in relation to nerve disorder and disease.

The cutting or wearing away of the anterior teeth by the tooth brush below the enamel on the lower jaw and above the enamel on the upper is no doubt due to a softening of the dentine from systemic and internal causes. Such teeth are easily cut with bur, excavator or drill. Their pulps are less sensitive and bleed less than normal in removal.

A boy with sound healthy enamel after recovery from pelvic abscess complained of his teeth feeling gritty. Dr. P. J. Kester found that the enamel had disintegrated.

In typhoid fever, the enamel becomes brittle and cleaves from about fillings and decayed edges. On the grinding surface of the teeth of those of middle-age, especially neurotics, the enamel wears away and the dentine is hollowed out as in erosion. Teeth which are soft with chalky enamel at one period may on the other hand become hard with organized enamel at a later period and stop decaying.

Dr. G. D. Boak states as to Philippine climatic effects upon the teeth: "While the weather is by no means as hot as it is at times during the summer in the States, the average temperature for the islands is about 89° F. It is a continuous heat without invigorating change of seasons. This gradually saps vitality and enervates, producing the lassitude which

is characteristic of the tropics. Enervation produces anemia, with corresponding lessening of the resisting powers from the lower vitality, especially in those who have lived previously in temperate climates. Caries is frequent and progresses rapidly in this climate." This Dr. Boak attributes to the following causes: First, lowering of the vitality by a lessening of the resisting powers; second, acidity of the oral secretions.

A strong, healthy young man of Irish parentage, twenty-one years of age, has been under my care for some years. He is of more than ordinary intelligence, perfectly healthy, and of an athletic build. His jaws measure two and one-half inches from the buccal surfaces of the first molars. He had thirty-two good, sound, hard teeth without a cavity. He contracted lues. In two years, his teeth softened with rapid decay, erosion, abrasion, discoloration and interstitial gingivitis. At the end of six years, the diseases have been arrested as well as the interstitial gingivitis, but the teeth still remain soft, and the usual history of decay is progressing. This is a typical but not uncommon case of hard teeth made soft by disease.

A typical illustration of soft teeth is that of a twenty-seven-year-old travelling salesman, one of my patients, who had a severe attack of jaundice one year ago. He came to have his teeth put in order. I found they had become yellow and soft; decay was progressing rapidly about the fillings; in excavating the cavities, there was no pain; the fibrillae were destroyed; if the pulps could be examined, they would be found diseased and receding in the pulp chamber.

It is not uncommon to find soft temporary teeth quite yellow, decaying rapidly and fibrillae and pulps destroyed: Master J. S. seven years of age, had measles at five. Recovery was slow; at seven is not strong. The permanent first molars, centrals and laterals are in place and are of a fairly good quality. The temporary cuspids, first and second temporary molars are soft, decay rapidly, pulps are reached without pain and the teeth are quite yellow.

I have a record of a number of like little patients. They have all had eruptive fevers and some have inherited disease.

Summary

Diseases of the tooth pulp cause discoloration, softening, erosion, abrasion, and diminish tooth resistance against rapid tooth decay.

When the dental pulp has finished its work of dentine formation it still retains its function of keeping the dentine alive.

Andrews and Miller have shown that soft teeth become hard; that

this nourishment is carried in the blood through the pulp by the dental fibrillae to the tooth substance.

Changes in density take place in the temporary as well as the permanent teeth.

The formation cells in that portion of the pulp nearest the point of repair are filled with new material for the purpose of repair. This repair is noticeable in some of those teeth which are worn down in old age. In most people, however, as age advances, the eliminating organs gradually become senile, and are sluggish, hence poisons remain in the system.

The dental specialist is not aware of the serious results which are progressing in the mouth and teeth because the patient does not appear to be ill. He is not ill, in a manner of speaking, because there are no ordinary symptoms of disease, yet from a stomatologic standpoint the early symptoms of disease are markedly present, as demonstrated by the condition of the jaws and teeth.

Metabolic toxemias and autointoxication poison the blood when more food is taken into the system than can be appropriated. These symptoms can best be studied by an examination of the urine. The two most important indications are indicanuria and excessive urinary acidity. Unless these symptoms be corrected serious conditions result. Their effect upon the pulp is to cause nerve-end degeneration, abscess and other degenerate states. When the indicanuria and excessive acidity are restored to normal, the blood, as a rule resumes its proper function.

The location, shape and peculiar structure of the dental pulp make it a favorable organ for disease. Its transitory and end-organ conditions cause it to be the most perfect tissue in the human body for the attacks of disease.

Diseases may be so severe as to involve the entire structure causing death of the entire pulp, or only circumscribed areas may become involved. Hence the entire tooth may discolor, soften, erosion and abrasion may result or decay may be very rapid. Again only certain areas of tooth structure may be involved.

Neurasthenia alone may cause nerve-end degeneration, destroy the fibrillae in the dental tubuli, and produce the same results. Neurasthenia may be acquired in the parent and transmitted to the child, or the child may acquire the disease. People with a nervous breakdown have diseased jaws and teeth.

Persistent grief and worry will so change the secretions of the body as to bring on faulty metabolism and excessive urinary acidity. Excessive mental strain will produce like results.

Degenerate children are more frequently observed with soft and decayed teeth than the non-degenerate.

The teeth of paretic dements and tabetics soften and decay rapidly. Severe illnesses will cause pulp destruction, tooth softening, erosion, abrasion, discoloration and tooth decay.

Climatic changes, such as those with which the soldiers contended in the Philippines and Cuba, cause lowered vitality and lessened resistance power, which bring about auto-intoxication, resulting in change of tooth structure through the dental pulp.

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